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New Guinea Agricultural Gazette—

Volume 1, Number 1.
Volume 2, Numbers 1, 2 and 3.
Volume 3, Numbers 1 and 2.
Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
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Volume 9, Numbers 1, 2, 3 and 4.
Volume 10, Numbers 1, 2, 3 and 4.
Volume 11, Number 1, 2, 3 and 4.

Copies of all numbers of the *Gazette* to Volume 7, No. 4, are out of print.

PLATE 1.—*Pyrethrum trials at Aiyura.*

PYRETHRUM IN THE HIGHLANDS OF NEW GUINEA

A. J. SCHINDLER.

Pyrethrum is a crop which has created a thriving industry in the Equatorial Highlands of East Africa. The author, who studied African pyrethrum production at first hand, has been in charge of the pyrethrum experiments of the Department of Agriculture, Stock and Fisheries of the Territory of Papua and New Guinea. Mr. Schindler describes methods of cultivation and selection of soils, which best suit New Guinea conditions. He reviews the firm market prospects for pyrethrum, despite the spectacular development of synthetic insecticides. His conclusion is that pyrethrum offers good possibilities, both for European and native planting in the Territory's Highlands. Mr. Schindler is Agronomist-in-Charge, Highlands Agricultural Experiment Station, Aiyura, Eastern Highlands.

A DAISY-LIKE plant, *Pyrethrum cinerariifolium,* of the Chrysanthemum group of the Compositae family, is the source of the valuable insecticide, pyrethrum. The plant has a flower head made up of a cluster of tiny flowers, consisting of an outside ring of "ray" florets and an inner mass of "disc" florets. The active constituents, or pyrethrins, are formed in glands at the base of the florets and are obtained when the flowers are crushed.

Pyrethrum has unique and important properties which enable it to withstand the competition of modern synthetic insecticides. It is one of the few insecticides which is completely harmless to man and animals. The active pyrethrins also have a quick knock-down power when applied to most insects. This knock-down is not completely lethal and some insects can make a recovery.

However, recent discoveries have introduced other substances, which although not lethal in themselves greatly increase the lethal power of the pyrethrins. These are known as synergists. One of the most common is piperonyl butoxide.

About 85 per cent. of pyrethrum is used domestically, about 10 per cent. goes to industry and the remainder is used in agriculture. Com-

mercial sources say that if the price of pyrethrum could be reduced the market could be expanded. In the last decade, there has been some pessimism about selling the world's pyrethrum crop in the face of competition from synthetics, but pyrethrum is, in fact, holding its own.

The price paid to farmers for dry flowers of 1.5 per cent. pyrethrin content varies from 2s. 6d. to 3s. (Aust.) per lb., and the yield an acre varies from 300 to 1,000 lb. of dried flowers. From an acre, the producer would expect to gross a return of £A40 to £A150. One pound of pure pyrethrum sells for about £A18 which allows roughly £A8 for manufacturing costs plus profit to the manufacturer.

The establishment of an extraction plant in Kenya has been the main factor contributing to the profitable production of pyrethrum in East Africa. The extraction plant at Nairobi was built about 1940 and a new plant is now being built at Nakuru. Before 1940, baled flowers were shipped abroad. These consignments lost weight during the sea voyage, the pyrethrin content deteriorated and little margin of profit was left to the grower. Now the extract is exported at concentrations of 15 to 20 per cent. pure pyrethrin and can be carried by air-freight. Previously, very careful picking was the rule at weekly or closer intervals. But picking can now be spaced at fortnightly or three-weekly intervals and this has brought about a big reduction in costs.

Soil and Climatic Conditions

Pyrethrum can thrive on a great variety of soils, if they are fertile. In Kenya, the soils of the pyrethrum-growing areas are derived from volcanic rocks, rich in plant food, and on the acid side of the pH range. Best conditions in East Africa are found on the recent volcanic soils and ashes around Lake Kivu, in the Belgian Congo and near the Kilimanjaro and Meru mountains in Taganyika. However, in Dalmatia, which is said to be the natural habitat of pyrethrum, the soil is light and calcareous.

Slopes liable to erosion are not suitable for pyrethrum because clean-weeding is essential and the bare soil is exposed to wind and water erosion for the three or four years the crop is in the ground. Flat or gently-sloping land is best.

An evenly-distributed rainfall is important for good pyrethrum yields and a healthy crop, because the plant is affected by drought or continuous hot and dry winds. Pyrethrum is also harmed by "wet feet" and where this is likely to occur drainage will be necessary.

Soils with natural free-draining textures are ideal for pyrethrum. They are found in many parts of the Highlands of New Guinea, although they do not necessarily occur over large areas. These soils can usually be cultivated easily and are often fertile. They therefore coincide with areas of heaviest population density.

The largest expanse of these open-textured soils is developed around Mount Hagen, and there are other significant areas in the upper Asaro Valley. Smaller areas are found in the Wabag area, on the Ramu-Purari divide, where the land is also quite hilly, in the valleys running into the Middle Wahgi from the north and south and in the valleys of the Finisterres. This survey excludes other Highland areas, such as those in Papua, which are unknown to the author.

Extensive trials will provide information about the usefulness of other soil types, such as the heavy clays of the Eastern Highlands, which do not possess good draining textures. No recommendation can yet be given for pyrethrum on these soils, because they are liable to waterlog in the wet and to cake hard in the dry season.

More information is also needed about pyrethrum possibilities on the organic soil of the pitpit swamp areas, which can be drained fairly easily, and which occur in many parts of the Highlands.

Optimum Altitudes

Close to the equator, pyrethrum produces best at altitudes of 8,000 feet or more. The limits of altitude are stated to be from 6,000 feet to 9,000 feet. The New Guinea Highlands lie about six degrees south, so favourable conditions should be found between 5,000 feet and 8,000 feet, with 7,000 feet and above as the optimum. However, verification of this will depend on the results of investigations into the response of pyrethrum in the Territory. The following table

shows how altitude and pyrethrin content are related to the effect of differences in mean temperature.

TABLE I.—Altitude, Temperature and Pyrethrum Content, Kenya Crop in 1956

Altitude in feet.	Mean Temperature Degrees F.	Pyrethrin per cent.
8,500	57.0	1.53
7,500	59.2	1.45
6,500	62.8	1.37

Much depends also on the particular temperatures prevailing about flowering time and it has been found that in general a rise in mean temperature by one degree results in a fall in pyrethrin content of 0.03 per cent.

Selection and breeding work is now under way at Aiyura with the object of producing strains capable of being grown outside the present altitude limits.

Yields

Preliminary plantings of many strains have shown that pyrethrum grows well at the Highlands Agricultural Experiment Station at Aiyura. Early extraction results from bulk flowers have also indicated that pyrethrum from Aiyura has a useful content of pyrethrin. It is expected that yields at Aiyura, which lies at an altitude of 5,400 feet, will average about 500 lb. of dry flowers per acre per year and that strains will be developed to yield more than 1.5 per cent. pyrethrin. On good soils at about 7,000 feet, crops of 1,000 lb. per acre should be expected. The expectation at 6,000 feet is 700 lb. per acre and at 5,000 feet 400 lb. is as much as could be expected. Confirmation of yields will depend on pilot plantings.

Preparation of the Land

(*a*) *Selection*

Choose flat or gently sloping land for pyrethrum. On flat land, even if the soil is of good open type, ridge planting will be necessary to provide drainage during wet periods. Where the land is gently sloping, some degree of protection from soil erosion will be necessary, together with ridge planting. On steep slopes special attention must be paid to erosion control measures and this work over a large area may be too costly. Pyrethrum is a suitable crop for planting immediately after grass has been ploughed out as long as the soil has not been ruined by former erosion or continual firing. Forest soils are, of course, also suitable.

(*b*) *Eradication of grass and weeds*

The preparation of the land is aimed mainly at the elimination of the hard stoloniferous grasses such as couch and kikuyu. They must not be allowed to build up again during the three years or more that pyrethrum is cultivated. Where such grasses exist several ploughings and cultivations will be necessary, followed by hand digging to extract the pieces of grass which remain. Where only tussocky native grasses are found, there would be no need for these measures. Where fields are to be only a few acres, as in early trial plantings, all the preparation of the land could be done by hand.

(*c*) *Anti-erosion measures*

On small areas, anti-erosion measures are hardly necessary but even so it would be wise to plan the field on the contour principle, so that the rows are level. If the soil is not porous the rows should slope slighly to allow the soil to drain easily. The field must also be protected at

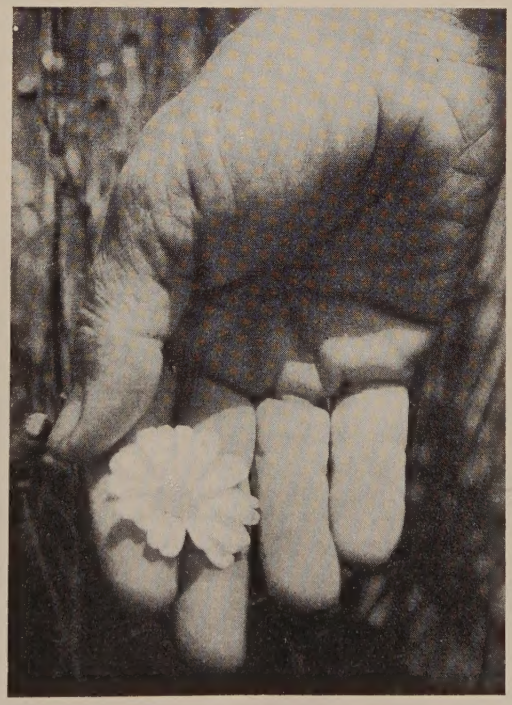

PLATE 2.—*The pyrethrum flower.*

the top by a drainage channel to prevent wash from higher land. A convenient slope for the drainage channel is a foot in 200 feet with a triangular cross-section 18 inches deep, three feet wide on the surface sloping to a point at the base. Where very heavy falls of rain are expected and channels are about 1,200 feet long, the cross-sectional area is increased and an early slope of 1 : 200 may be increased to 1 : 100 along the channel to carry off large volumes of water.

A basic line at the top of the field is run out by dumpy level or by striding level (A-frame) and marked at intervals. To obtain the slope, one leg of a six-foot A-frame has a piece of wood a third of an inch thick nailed to the bottom of it. If a slope of 1 : 100 is required, the piece of wood should be two-thirds of an inch thick. The basic line is followed when making the protection drain. The same line is followed when running out the first planting ridge.

Where larger areas are planned, consideration must be given to further anti-erosion measures. The extent of these measures depends on the slope of the land, the nature of the soil and rainfall. The first operation is to decide where to run off the water, the second is to find the average slope of the field and the third is to mark the position of each drainage channel. The frequency of the drainage channels determines the quantity and velocity and hence the erosive power of the run-off water. The table on the next page will give an indication of the spacing between the drainage channels.

(d) Throwing up the ridges, fertilizing

The field should be ready when the nursery plants are four to five months old. Final cultivation should be done in the week before transplanting, when the ridges should be thrown up.

Overseas experiments have shown that on grassland soils, phosphate at the rate supplied by two to three hundredweight of 18 to 20 per cent. superphosphate an acre will increase the yield of flowers over the three years by up to 20 per cent. The superphosphate must be applied to the soil under the pyrethrum rows just before planting and before throwing up

PLATE 3.—*Ridged cultivation of pyrethrum at Aiyura.*

the ridges. However, fertilizing in Papua and New Guinea cannot yet be recommended until field trials have been made to test its value.

The ridges are made by following the drainage channel and using it as a guiding trace to build parallel ridges so that the furrows between the ridges act as drainage ways with a slight slope similar to the channel. If a considerable area has been prepared and more than one drainage channel crosses the field, then the ridges on the upper half of the field are made parallel to the upper drainage channel and the ridges on the lower half are made parallel to the lower channel. The untouched spots are worked in later. This preparatory work should be done accurately, particularly if mechanical cultivation for later weeding is planned. The ridges for double row planting are made two feet wide. If single row planting is proposed, the ridges are made one foot wide.

TABLE II.—Intervals Between Channels.*

Slope of land feet per 100 feet	Vertical drop between channels feet	Distances between channels in feet	Lineal feet of channel to give an acre between channels
2	3	150	300
4	4	100	430
6	5	83	520
8	6	75	570
10	7	70	610
12	8	66	650
14	9	64	670
16	10	62	700

(* Adapted from Table 10, "Soil Erosion and its Control", Ayres, McGraw-Hill).

In East Africa, pyrethrum is planted at rates of from 14,500 to 22,000 plants an acre. The higher density should suit the New Guinea Highlands, where drought is usually not a problem. The best method of planting is to have the plants in double rows on a low ridge and to have the ridges four feet apart. The plants in each row go in one foot apart, staggered into the double row as in triangular planting. This system leaves three feet of working space between the double rows for either a small cultivating machine or a machine which straddles a double row, while operating two or four cultivating attachments on its tool bar.

Another method of spacing to give the same number of plants per acre is to have single rows two feet apart with the plants again spaced in the row at one foot apart.

Establishing the Crop

Planting Material

The first introduction of a new variety of pyrethrum to a plantation is usually by seed. This must be from a high-yielding strain, proven by chemical analysis and of good agronomic character, uniform and not subject to lodging.

Further multiplication may be done from splits of the existing proven high-yielding plants. A well-grown vigorous plant will split into five or ten pieces for planting. To extract splits from a mature field, the old field must be examined and all weakly, sickly, lodged and non-flowering plants dug out. Three or more acres of old field will probably provide enough splits to plant ten acres of new field. The plants remaining are dug out with forks during favourable weather and the old flowering stems and half the foliage is cut off. When dividing the plants ensure that each split retains many roots. Splits have a certain advantage over seedlings when conditions are wet as the slender seedlings may be overwhelmed by surface water. Splits also flower earlier than seedlings.

Seedlings, with a strong root system do better in dry weather. For their production a nursery is necessary. If it is proposed to plant a second time by seed, it is necessary to go back to the cross between the original parents of the variety, as the seed produced by the second generation in the field will not produce the same high quality plants as those which come from the original cross.

Nurseries

The viability and germination percentage of seed can vary and hence the amount of seed required will also vary. Forty per cent. germination can be expected from good seed and at this rate three-quarters of a pound will plant an acre. The seed is planted in the nursery bed at an ounce to 100 sq. ft. of nursery. The requirement, then, for one acre in the field is 1,200 sq. ft. of nursery bed.

The nursery should be established where there is well-drained rich soil with a water supply close by. Usual nursery bed technique should be observed. The beds should be four feet wide separated by paths 18 inches wide. The soil

should be cultivated to a fine tilth and raked level. The seed should be drilled in rows across, or along the bed, at the rate of about ten seeds to the inch if the drills are four to five inches apart.

The seeds are slightly covered by fine soil and grass mulch should be laid on the surface. Avoid over-watering. The seed starts to germinate in ten days and all viable seeds are germinated within a month of planting. At first, as the plants develop, frequent light waterings should be made. Later heavier and less frequent applications are necessary to encourage good rooting. When germination commences, the grass mulch must be removed. In some seasons a light shade canopy will help the young plants. The shade if used should be removed after the seedlings have made a month of growth.

At four to five months old, the seedlings are ready for transplanting to the field in suitable weather.

early April in the Highlands. The land should not be too wet or it will become puddled as labourers continually tramp it down. The nursery plants are dug out deeply to avoid root damage and are carried to the field in baskets or bags. The planter is armed with his planting stick, which is also used for measuring as described above. With this he makes the holes as he goes along the ridge, carrying at the same time his bundle of plants. He drops the roots of each plant into the hole, taking care not to curl them up, and firms the soil around them with his foot. It is certain that a few plants will fail to take and these must be replaced without delay by new and well-grown plants.

Care and Cultivation

Weed growth, if not prevented after planting, will soon ruin the field. Weed growth at any time will greatly reduce the yield. Ridged fields can be weeded in the furrow by the tractor ridging attachment running through and throwing

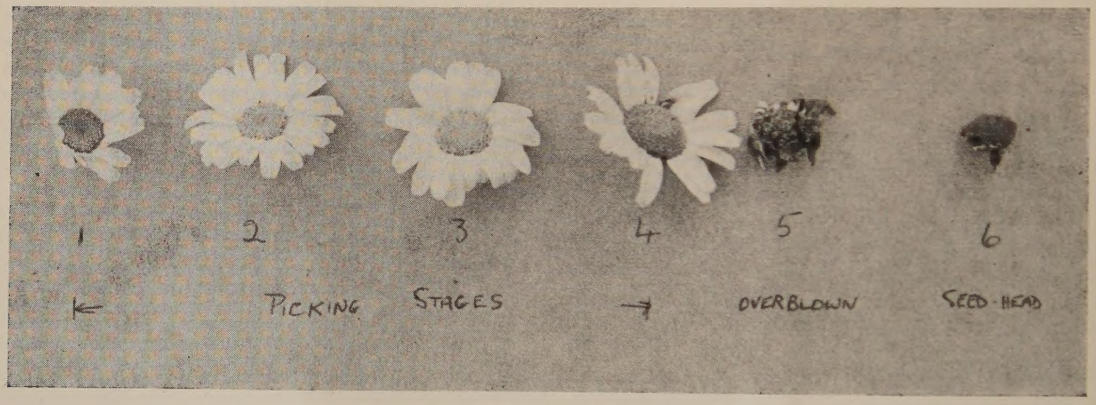

PLATE 4.—*Stages of Pyrethrum flowering.*

Transplanting—(a) Marking Out

Accuracy is unnecessary as the plants on the ridge itself must be weeded by hand. Each planter carries a stick to show him the distance between the plants. If he is planting single row, the stick is a foot long. If he is planting double row, the stick is 14 inches long and the planter must be taught to lay it down diagonally from plant to plant. The sticks should be strong and at least an inch in diameter and sharpened so they can also be used for digging.

(b) Planting

Generally, good transplanting weather would be almost any time between early December and

some soil back over the ridge. Hand weeding will be necessary among the plants on the ridge. Any invasion of couch grass must be dug up and removed by hand.

Once a year, the old flowering stalks which remain behind after the flowers have been picked must be cut back as far as the level of the foliage with a sickle or a pair of hedge clippers.

Pests and Disease

Pyrethrum until recently has been very free from diseases and it is expected that there would be few problems with the crop in New Guinea for some time.

In 1946, in Kenya, a fungus *Ramularia bellunensis* began to attack pyrethrum, and has become rather troublesome. It attacks the flower heads, causing them to twist and become deformed and all affected buds fall off before maturing.

Individual plants in a field may develop root rot but this is not serious except in old fields.

Nematodes may become serious in some fields and in many places their presence makes rotation essential.

Harvesting and Processing

Picking

There are several stages recognized in the ripening of the flowers. After the bursting of the bud the immature flower stands with its white petals vertical, before they turn down to the horizontal position. Then the yellow ray florets commence to open on the outer edge of the flower. After some days, the whole of the disc florets are open and the stamens and styles die leaving the flower in the "overblown" condition. The time from bud-burst to overblown varies according to the season, but is usually about a fortnight and the periods between harvesting will vary accordingly. The best system of harvesting is to pick often enough to avoid the overblown flowers. The period will vary around two weeks. Buds and immature flowers with vertical petals are not to be picked but all maturing flowers at all the other stages are harvested. The removal of young flowers with petals horizontal stimulates the plant to produce more flowers. However, if flowers are permitted to become overblown, this will place too great a strain on the plant and subsequent flowering is reduced.

The flowers are broken off just under the disc, ensuring that no stem is taken with the flower. Flowers should not be picked while wet with dew because they may ferment and overheat before the first drying. The flowers should not be crushed when put into the pickers' baskets. An average day's harvest for one picker when the flush of flowers is on the plants is 40 lb. of fresh flowers. Four pounds of fresh flowers yield about one pound of dried flowers.

Drying

Sun-drying is satisfactory for small areas and where sunny days can be expected. However, prolonged dull humid weather may cause the half-dry flowers to ferment and to lose some of their pyrethrum content. Where a crop is yielding at the rate of 800 lb. of dry flowers an acre, a peak day pick over one acre may be expected to yield 280 lb. of fresh flowers. Drying trays should not be loaded with more than one pound of fresh flowers for each square foot of tray. At a spacing period of two weeks between harvests and in sunny weather the day's harvest should be dry before the next harvest comes in, hence one would require not less than 280 sq. ft. of trays for each acre. A well-protected shed is necessary for storing the trays at night or in wet weather.

In hot-air drying, the usual practice is to have two or three trays in a cabinet, through which a draught of hot air is blown. A drier can be built on the farm if a heat-exchanger and a fan and a small motor are obtained. Slow draught driers use temperatures no greater than 140 degrees but newer forced draught driers can employ temperatures as high as 190 degrees. In the former a charge of fresh flowers will be dried in about ten hours, but in the latter one or two hours will suffice to complete the drying.

Faults in drying are fermenting, steaming or scorching the flowers. Fermentation is caused by leaving the fresh flowers in wet piles awaiting a place in the drier, by drying too slowly, or by heaping too deeply. Steaming is brought about by high temperatures accompanied by poor air circulation. Scorching is caused by high temperatures or contact with very hot plates.

Packing

After drying, the flowers are allowed to cool before packing. If the extraction centre is close at hand, ordinary jute bags could be used, but if the flowers are to be sent a long way they may be subject to deterioration due to contact with air and moisture changes and packing in polythene bags may be desirable. The flowers must be lightly packed to prevent breaking them up with subsequent loss through open mesh bags. If it is necessary to store flowers they must be placed in a cool dry place.

Economics of Production

Life of the Plantation, Rotation

Only under the very best of conditions will a plantation remain profitable for more than four years from first flowering and three years is a

more general expectation. Weeds slowly enter the field and more and more frequent weedings become necessary. Plants tend to die from obscure causes which are expensive to combat. The numbers of destructive pests such as nematodes increase with time. As the pyrethrum crop diminishes the operator must seek a renumerative rotation.

In Kenya, where there is local production of grains and pastoral products, very favourable rotations have been found. Pyrethrum is planted for four years, wheat for one season, then the fields are planted to grass and grazed for three to four years. Nematodes disappear and the soil structure improves immensely after the compaction it has suffered under the pyrethrum crop. Suitable rotations for New Guinea cannot yet be anticipated but the best results will probably be obtained from some of the grain or grass crops.

Extraction

Extraction is a complex chemical process and will be one of the largest problems confronting the establishment of a pyrethrum industry in New Guinea. Some interest has been shown by chemical firms in Australia, however, and it may prove economical to erect an extraction plant in New Guinea to deal with fresh flowers if the farm production of pyrethrum becomes a part of Territory agriculture.

Production Costs

Farm production does not demand a high capital cost. Small areas can be worked by hand labour alone. Agricultural machinery can be used for most cultivation and weeding operations if the fields are laid out so that the implements can work between the rows. However, the farm work is essentially for hand labour and machinery would replace little more than one-quarter of the labour force.

The approximate expenditure in units of labour can be determined from Kenya figures and from New Guinea experience with labour (see Table III).

Summary

For suitably well-drained soils at elevations above 5,000 feet in the Territory of Papua and New Guinea, strains of pyrethrum are available which will produce satisfactorily. It is confidently expected that further improved strains will be selected and developed.

As a farm crop it could be developed as a subsidiary to other types of farming, but there is little to indicate at the present that pyrethrum could become a main crop or sole crop for a plantation.

Pyrethrum offers great possibilities as a native farm crop, being especially suited to small plots, hand labour and requiring little capital.

Extraction and marketing are the main difficulties and much has yet to be done in discovering an outlet for the Territory's potential production.

TABLE III.—Estimated Labour Expense in Units On One Acre for Three Years of Pyrethrum Production.

Item	Labour units	Labour units if assisted by agricultural implements
Nursery preparation and care for five months	90	90
Transplanting	40	40
Preparation of land. Cutting Grass. Two diggings, one channel, ridging	100	30
Weeding for three years	240	100
Harvesting for three years	300	275
Baling, drying	60	60
TOTAL	830	595

PLATE 1.—*Extensive coffee plantation in a highland area, of Costa Rica.*

COFFEE PRACTICES IN CENTRAL AMERICA, THE WEST INDIES AND HAWAII

J. W. BARRIE.

The author is an extension officer of the Department of Agriculture, Stock and Fisheries of Papua and New Guinea. He was formerly District Agricultural Officer in the Eastern Highlands of New Guinea, but is now attached to the headquarters of the Division of Extension. Mr. Barrie's other publications in the Journal include an article on coffee-growing in the Highlands and also a survey of land and population pressures in the Chimbu Subdistrict. He made the tour, referred to in the present article, in 1958, *following a course at the Imperial College of Tropical Agriculture in Trinidad.*

DURING a recent agricultural study tour which included Central America, the West Indies and Hawaii, the writer was able to observe coffee production techniques in a number of the countries visited. Because of other commitments, the time available for visiting coffee plantations, and coffee processing and marketing centres was often limited.

Coffee-growing areas visited included Trinidad, Costa Rica, El Salvador, Guatemala, Mexico, Jamaica, Puerto Rico, and the Kona region of Hawaii.

As could be expected, the size of plantations varies greatly. In Hawaii there are few plantations of more than 20 acres in area. Plantation size in Central America varies from many small holdings of approximately five acres to large holdings of 500 acres or more.

Visits to the coffee centres were often brief. As a number of countries were visited in a relatively short time it is difficult to present a

general picture of coffee-growing techniques in each of the countries visited. It is proposed to record in this article observations under the following general headings :—

1. Varieties.
2. Soils and climatic conditions.
3. Plantation management.
4. Harvesting.
5. Processing.
6. Grading and marketing.
7. Summary.

To avoid repetition of information previously published in the *Papua and New Guinea Agricultural Journal,* reference should be made to an earlier article by the writer entitled *Coffee in the Highlands.* (Vol. 11, No. 1, July, 1956.)

Varieties

With the exception of Trinidad, the bulk of coffee produced in the foregoing countries is "arabica" or highland coffee (*Coffea arabica* Linn.). Trinidad production is small and is mainly "robusta" coffee, (*Coffea canephora* Pierre ex Froehner).

Throughout the arabica-producing countries, established plantings are mainly of bronze-tipped typica strains. However, it was evident, particularly in Costa Rica, El Salvador and Guatemala, that there has been a decided trend in favour of the green-tipped bourbon varieties. Many of the new plantings are of bourbon varieties. Technical officers engaged in coffee research and extension workers in these countries are of the opinion that the acreages of bourbon plantings should be greatly increased. Both by observation and through speaking with these men it was apparent that in Central America and Hawaii bourbon coffees behave similarly to bourbon coffees grown in the New Guinea highlands. Yields are said to be generally higher than typica varieties. The bourbons appear to be more vigorous and sturdier, especially at the lower altitudes. Under drier conditions also, the bourbon coffees are proving to be more suitable than typicas. Tests at the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica, have indicated that the liquoring qualities of the bourbon coffees are not inferior to typicas.

The merits of the bourbon coffees are recognized by research and field men familiar with coffee production. There remains among many growers, however, the inherent prejudice of changing from one coffee variety to another. In Costa Rica for example, growers have long become accustomed to producing typica varieties with a large bean. Before the war the bulk of the high grade Costa Rican coffees was exported to the German market, which paid a premium for coffee with a large, bold bean. The Costa Rican growers therefore catered for this demand.

A brief description follows of a number of varieties that were seen.

(i) Caturra—A dwarf high-yielding bourbon variety, which is usually planted at a closer spacing than other bourbon and typica varieties.

(ii) Bourbon and Yellow Bourbon—The yellow bourbon, in which the ripe cherry is yellow, is a selection from bourbon and generally outyields that variety.

(iii) Villalobis—A common bourbon variety in Costa Rica.

(iv) Mundo Novo—A further bourbon selection from Brazil.

(v) Villa Sarchi—One of the more recent bourbon selections which is claimed, in Costa Rica, to be more adaptable to poor drainage conditions.

(vi) Pacas—A recent bourbon selection in El Salvador. Under experimental conditions this variety is growing extremely well without shade, and gives promise of being a high-yielding variety.

(vii) *Arabica* (Typica)—Refers to the bronze-tipped typica strains. All of the typicas produce a larger green-bean than the bourbons.

(viii) Blue Mountain—A typica variety. The genuine Blue Mountain coffee, from the Blue Mountains of Jamaica. In Jamaica the crop is small but of high quality. The coffee is of bluish-green appearance, very mild and sweet tasting in the cup, and pleasantly aromatic. In Central America it is thought that Blue Mountain is not as drought-resistant as and lacks the vigor of other typica selections.

(ix) San Ramon—A dwarf variety with short internodes and small leaves. This variety is said to have originated from the San Ramon area in Costa Rica. Although of little economic importance it is claimed to be useful for planting in exposed positions and under drier conditions. In appearance San Ramon coffee closely resembles the dwarf variety that occasionally appears in plantings through the highlands of New Guinea.

(x) Hybrids—Of interest were the first plantings of a hybrid, bourbon x typica cross. These plants were seen at Turrialba and at the time of the visit they were about eighteen months old and appeared to be very vigorous. On the basis of varietal improvement the Central American countries are conducting breeding and selection programmes. Varietal trials, breeding studies and progeny testing trials were observed in Costa Rica, El Salvador and Mexico.

Soil and Climatic Conditions

The soils and climatic conditions are rather similar to those of the Territory coffee areas. Plantings generally are confined to fairly fertile soils and particular emphasis is placed on providing good drainage.

Severe dry seasons of five months' duration are not uncommon in some regions. Where adequate shade and fertilizer is provided, the coffee plantings do not appear to be unduly affected by the protracted dry conditions. Variations in annual rainfall range from about 50 inches in drier areas to more than 120 inches in the wetter areas of Costa Rica.

Coffee is grown from 1,000 feet to 5,000 feet, with the bulk of plantings, except in Hawaii, being between 2,500 feet and 4,000 feet. At the higher altitudes, yields are generally lower but the quality is reputed to be superior to lower-level coffee.

Plantation Management

Because of the relatively high cost of labour, plantation management techniques aim at reducing labour costs to a minimum. There is a marked seasonal demand for labour during the height of the picking season, usually from November to March, but in the ensuing time labour strength is reduced to a minimum.

PLATE 2.—*Hawaiian picker using pandanus basket and low-level ladder to harvest multiple-stem coffee.*

Nursery Procedure

The coffee seed is usually thickly broadcast on to small well-prepared seed-beds. Shortly after germination, at the two-leaf seedling stage, the more vigorous seedlings are pricked out into larger nursery beds, at an approximate spacing of six inches by six inches. In some cases the seedlings are left in these beds until transplanting to the field. Often a third transplanting occurs when the seedlings are fairly well-advanced. Seedlings are usually transplanted to the field from 12 to 18 months after sowing in the nursery. Shading of the nurseries is usually discontinued after the first transplanting.

Transplanting

The usual practice is to transplant complete with a sod of soil around the roots—this is

termed "pilon" planting. By this method the transplanted coffee seedling suffers only a minor setback. No great emphasis is placed on digging large holes for field planting.

Planting with a sod of soil is also common in Hawaii. However, the "root-snapping" technique (reference *Coffee in the Highlands*) carried out approximately six weeks prior to field planting ensures a firmer sod-retention and also minimizes the danger of bench-root plantings.

Overlong or dangling roots are pruned short before planting in the field.

Spacing

Spacing distances range from about 6 feet by 6 feet to 13 feet by 13 feet, both on the square and the triangle. The tendency is for closer plantings to decrease or even eliminate weed-competition and to minimize the amount of pruning required. The closer plantings also afford a degree of self-shading as there are correspondingly larger numbers of trees per unit area. Although the closer spacings do result in lower yields per tree, it is claimed that this disadvantage is offset by the reduced management costs, particularly pruning and weed-control.

Two systems of hedgerow planting are worthy of mention. In El Salvador, a hedgerow system consisting of two rows of bourbon coffee, spaced 3 feet 6 inches apart and 3 feet 6 inches between plants in the row, with a 10-foot interval between the double rows. The particular planting was growing without shade and looked very impressive. This form of planting would appear to be most applicable for contour planting on sloping land.

Another modification of hedgerow planting consists of three rows of coffee with a spacing of 3 feet 6 inches between and within the rows and a 10-foot interval between the groups of three rows. In this system the middle row of each group of three appears lower yielding and less vigorous. From observation, the two-row hedge system seems better than the three-row system.

The aim of hedgerow planting is to provide the greatest possible degree of self-shading and so minimize the need for shade trees. Hedgerow systems also aim at preventing overbearing and die-back.

A further planting technique, the principal object of which is to produce a large output of coffee for a limited number of years, is the "hill-planting" technique. In this system three to four trees are planted about 18 inches apart in a clump, with a spacing of 14 feet to 16 feet between clumps. Heavy fertilizing and irrigation results in accelerated growth and heavy yields.

Shade and Windbreaks

There is a variance of opinion on the value and amount of shade required. Unanimous agreement favours the necessity for windbreaks.

In each of the countries visited both shaded and unshaded plantings were seen. Shade provision varies from light and seasonal to heavy and permanent shading. Hawaii was the only country visited in which most of the plantings are unshaded. In the Kona area of Hawaii, as in certain areas of Central America, unusual climatic conditions, peculiar to the area, allow successful coffee production without shade protection. In the Kona district, local cloud formations develop over the coffee areas in the early afternoon and so protect the unshaded plantings from prolonged exposure to the sun. Similar local conditions occur in some of the higher rainfall coffee areas of Central America.

In both Jamaica and El Salvador, unshaded bourbon plantings are growing successfully in areas with an annual rainfall of approximately 70 inches and a pronounced dry season of at least four months' duration.

Of late there has been a tendency to reduce shade intensity and increase the rate of fertilizer application, the aim being increased yields. Field experiments have indicated that there is an inverse-relationship between shade intensity and response to increasing fertilizer rates. Furthermore, fairly heavy fertilizer applications fail to give as significant a yield response under dense shade as under light or no shade.

There is no overall preference for any one shade species. Bananas, citrus, *Grevillea* sp., *Inga* sp., *Erythrina* sp., and endemic species are all used. Tall-growing bananas are preferred for temporary shade.

The leguminous *Inga* sp. is widely used for permanent shade in Costa Rica. This species is tolerant to severe pruning, in that it can be pruned right back at the beginning of the wet season. New leaf growth develops during the

rainy season so that by the beginning of the dry season there is enough foliage to provide adequate shade for the dry season. At the beginning of the next wet season the tree is again pruned right back. The leaf prunings serve as a mulch and the heavier timber is utilized for fuel. From observation, the *Inga* sp. appeared to be the most suitable coffee shade tree in Central America.

Soil Erosion Control

In the coffee areas of Central America and the West Indies, it is not unusual to see coffee growing on steep hillsides. Land with a 50-degree slope may be planted in areas of land shortage. Successful coffee cultivation is possible on such land as a result of the effective anti-erosion measures adopted by the coffee farmers.

On the very steep land, the coffee trees are usually planted on individual bench terraces with the terraces on the contour. Bananas are commonly planted between the terraces to help hold the soil and to provide food and shade.

Another form of erosion control is to plant almost on the contour, with the trees closely spaced in the row. The spacing between the contour rows is correspondingly larger. Between the contour rows and also the ends of the rows, silt pits are dug to accumulate the eroded soil. The silt pits are emptied from time to time and the soil is placed along the contour rows. Although this is a time-consuming practice it is a very effective method of retaining topsoil on steep land.

In other areas, contour drains with retaining hedges of either yucca, pineapples, sisal, bananas, or some grass species are planted. On land in which the slope is not excessive, the combination of permanent shade and closely-spaced plantings is usually regarded as sufficient for erosion control.

Mulching, although not extensively practised, serves a secondary function as an anti-erosion measure.

Weed Control

On a number of plantations visited, weed control did not present a problem as the fairly-closely spaced multi-stem plantings provided a complete canopy overhead. Under such conditions there is practically no weed growth.

With the open planting systems, including the hedgerow methods, weed control is regarded as an important phase of plantation management. On well-managed plantations chemical weed control is considered to be more economic than manual or mechanical weeding.

A number of herbicides have been tried to date, 2,4-D and Dalapon (as Dowpon) have proved most effective. A mixture of 2,4-D and Dalapon with diesel oil and water has proved very effective for mixed weed control and may be sprayed right up to the trunk of the tree. Depending upon the severity of weed growth a general rate of application would be in the order of 15 gallons per acre of a mixture of :—

Dalapon (Dowpon)	2 lb.
2,4-D (Dow 40)	2 lb.
Diesel Oil	20 gal.
Water	20 gal.

Fertilizing

The use of artificial fertilizers is not an accepted practice generally. Over the last ten years, however, there has been an increased use of fertilizer, particularly on the larger plantations. Composting and mulching, rather than fertilizing, is practised extensively on the smaller coffee holdings.

Good use is made of the coffee pulp for composting. The fresh pulp may be buried in pits between the coffee trees, but in general, compost made of pulp and other material, usually farmyard manure, is preferred. This is a common practice in Costa Rica where dairy farms are run in conjunction with small, highly productive coffee farms. Elephant grass (*Pennisetum* sp.) is grown for the stall-fed dairy cattle. A visit was made to a better example of one such farm in Costa Rica. The farm had a total area of 32 acres on which the owner managed 110 dairy cattle and 12 acres of first-class coffee. The cattle were entirely stall-fed from Elephant Grass grown in rotation plots on the farm and cut daily for feeding. Both the grass plots and coffee were fertilized from compost made of coffee pulp and farmyard manure.

The use of artificial fertilizers to boost yields is standard practice in Hawaii, because of the rather shallow and rocky nature of Hawaiian coffee soils. One, two or three applications of 10-5-20 N-P-K fertilizers are made during the growing season. An application of sulphate of ammonia is recommended near the end of the wet season. This has a beneficial effect in combating die-back during the dry season. A complete fertilizer containing 10-10-10 N-P-K is recommended during the first year of growth in the field to ensure a more vigorous and well-developed tree in its early cropping cycle. Fertilizer application rates, particularly for the 10-5-20 N-P-K mixture, range as high as one ton per acre per annum.

PLATE 3.—*Newly-planted coffee seedlings in recent volcanic rocks, Hawaii.*

There does not appear to be any generally accepted fertilizing programme in the Central American coffee areas. Sulphate of ammonia and 10-5-20 N-P-K are both used. The increasing use of 10-5-20 N-P-K appears to be a result of extensive fertilizer experiments in Hawaii.

In connection with the nutrition of the coffee plant, the technique of foliar analysis for diagnosing apparent major and minor element deficiencies has been well developed in Costa Rica. Coloured guide charts showing typical leaf patterns and foliage conditions for specific element deficiencies are available to growers.

Field workers claim that deficiencies of either nitrogen, phosphorus, potassium, iron, manganese, magnesium, boron, or zinc can often be recognized in the field. The following notes describe rather briefly the typical deficiency symptoms for the above major and minor elements :—

Nitrogen :

A general yellowing of the leaf, similar to unfertilized coffee grown with little or no shade. The first symptom is usually a yellowing of the leaf margin which may extend to give a blotchy yellow coloration over most of the leaf. There is some doubt as to whether the nitrogen deficiency causes a carbohydrate deficiency or vice versa. The recovery of a healthy leaf colour usually follows the application of a nitrogenous fertilizer.

Phosphorus :

Typical deficiency symptoms occur in the older leaves particularly on branches carrying a heavy crop. The leaves tend to change colour from the tip end and extending over the leaf. Yellows, reddish-yellows and reddish-purple colours may develop. The deficiency is remedied by phosphatic fertilizers.

Potassium :

Severe deficiency results in stunting and leaf fall. Die-back and blackening of the young growth, starting from the tip, is a recognizable symptom. Potassic fertilizers remedy the deficiency.

Iron :

Iron deficiency can be recognized by the typical "fish-net chlorosis" symptoms. These appear as a pale greenish-yellow leaf colour against which the leaf venation is clearly outlined. Because of the interaction between iron and other elements, iron deficiency symptoms may occur due to an imbalance in the plant between iron and some other element. This is noticed in Costa Rica where an imbalanced P/Fe ratio in the leaf may produce iron deficiency symptoms.

Manganese :

The deficiency symptoms for this mineral are said to vary slightly, depending on the degree of coffee shading. With well-shaded coffee, the terminal leaves change to a greenish-yellow colour with white spots developing. The older and more mature leaves retain their dark green colouring. For unshaded coffee, the colour changes are said to be more pronounced, changing from a yellow colour at the tip to a pale green for more mature leaves. The white mottling effect remains.

Magnesium :

Well-defined interveinal bronze areas of the older leaves characterize a magnesium deficiency. Before changing to a bronze colour the interveinal areas are successively pale-green, yellow-green and yellow in colour. The deficiency is controlled in Costa Rica by the application of magnesium sulphate.

Boron :

Typical deficiency symptoms include a fan-growth effect and die-back of the terminal shoots. Leaf distortion is also characteristic of boron deficiency. Spectacular yield increases have occurred in certain areas of Costa Rica from an application of two ounces of borax to the soil around the base of each tree.

Zinc :

Zinc chlorosis deficiency symptoms are somewhat similar to iron chlorosis symptoms. With zinc deficiency, however, a typical development is the formation of terminal bunches of small, chlorotic leaves. The bunch development results from a shortening of the internodes. Severe leaf fall may also occur. The deficiency is controlled by zinc sulphate sprays.

Pruning

Most plantings are pruned to develop the agobiada multiple-stem framework. Single-stem coffee was seen only in Jamaica. In the Central American countries the young seedling is bent over and pinned down to induce the growth of verticals for the multi-stem framework. The same objective is achieved in Hawaii by planting the coffee seedling at a 45-degree angle. For a more detailed account of the agobiada system, reference is made to *Coffee in the Highlands*.

Once the multiple-stem framework is developed, little further pruning is practised, except that from time to time low-bearing branches are cut out and replaced. Regular pruning did appear to be a more important phase of plantation management in Hawaii. The basis of multiple-stem pruning in Hawaii is to remove one vertical each year and allow one or more replacements to grow up as required. The tree can thus be cropped and pruned to a regular cycle varying from four to six years.

A modification of the agobiada system seen in El Salvador involved capping of each of the multiple stems. The numerous bifurcated stems produce a candelabra-shaped coffee tree. This more involved pruning technique did not appear to have any additional advantages over the less complicated agobiada system.

A further pruning technique worthy of mention is the Beumont-Fukunaga system. This system is only a recent development and under experimental conditions it has resulted in extremely high yields. Briefly the pruning procedure is as follows. The coffee plantation is first divided into blocks, each block consisting of four rows of coffee. In the first year of pruning the first row of coffee in each block is stumped after the crop has been harvested. In the second year the third coffee row in each block is stumped. By this time new verticals should be developed on the first row, stumped in the previous year. Similarly, in the third and fourth years, the second and fourth coffee rows respectively are stumped. Thus at the end of a four-year cycle the whole plantation has been pruned to give a complete renewal of bearing wood. Stumping back is done at the end of the picking season. Heavy fertilizing with little or no shade is recommended with the Beumont-Fukunaga technique. Even with heavy fertilizing it is considered unlikely that very high yields could be maintained for more than a few years.

The Beumont-Fukunaga system aims at producing very high yields with minimum pruning costs. Pruning can be carried out quickly without the use of skilled labour. By stumping the first, third, second and fourth rows in successive

PLATE 4.—*Development of the multiple-stem framework.*

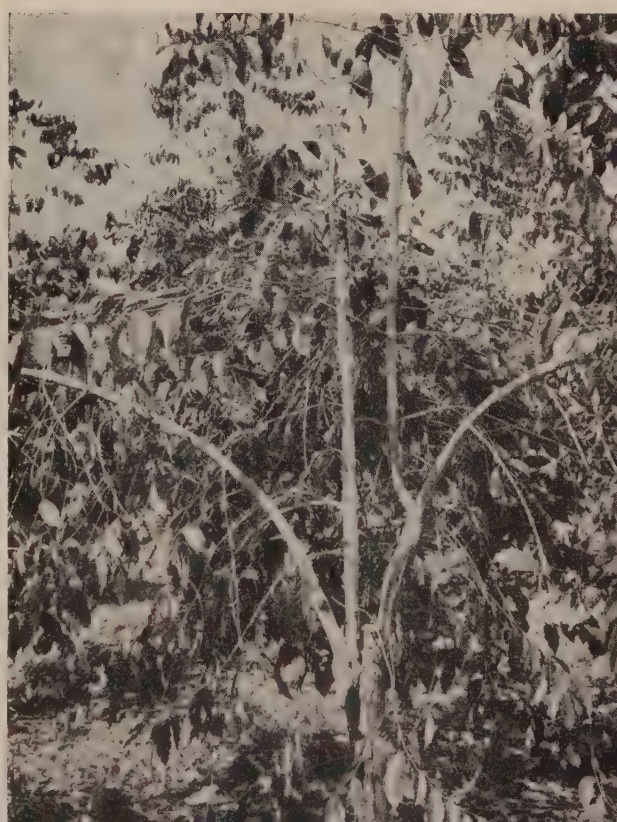

PLATE 5.—*Rejuvenation of old coffee in Hawaii by stumping back.*

years, a degree of wind protection and mutual shading is afforded by the adjoining rows. Trials are being conducted using various spacings both between and within the coffee lines to determine which distances are likely to provide the maximum mutual shading.

To date the Beumont-Fukunaga system has not been recommended for areas which are subject to severe dry seasons. Under protracted dry conditions sucker development after stumping could be disappointing. Irrigation might offset the effects of prolonged dry conditions. Another alternative is that one vertical be left when each tree is stumped, to serve the same purpose as a "lung" branch in converting single-stem trees to a multi-stem framework.

Harvesting

Picking is done on a task basis with men, women and children participating. The picking season extends over a number of months with the bulk of the crop maturing between October and March.

To reduce labour costs for harvesting, the number of pickings is confined to a minimum of rounds—sometimes as low as three rounds per season. Up to 120 lb. of cherry is said to be a good day's picking. In Hawaii it was interesting to note that very light and inexpensive picking bags can be made from plaited pandanus leaves. The bags are strapped over the pickers' shoulders to allow two-handed picking. As a result of the small number of pickings per season, a percentage of the harvested coffee may be over-ripe or "buni" coffee. Low ladders are used where the multi-stem trees are too tall or cannot be bent over to allow picking from the ground. It was difficult to obtain approximate yield figures, although a yield of half a ton of green coffee per acre is regarded as good. With intense fertilizing in Hawaii, yields of one ton per acre are not uncommon.

Although the aim is to pick ripe cherry only, it was stated that unless periodic inspections are carried out partly-ripe cherry may also be harvested. The Government of Costa Rica aims at maintaining the high quality for which the country is known. Coffee inspectors travel around the country during the picking season to see that only ripe cherry is being picked and processed. It is an offence to pick and process either under-ripe or over-ripe coffee with fully ripe cherry.

Processing

Processing is carried out in large central mills, completely equipped to ensure the best possible quality coffee. The central mills usually process about 24,000 tons of cherry per year. One large mill visited in El Salvador annually processed 40,000 tons of cherry. A smaller but expertly-designed mill in Costa Rica processed 20,000 tons of cherry a season. The drying facilities for the latter mill included four acres of concrete barbecues, with 24 rotary hot-air driers.

Coffee is purchased from the growers by the central mills either in cherry, parchment, or buni form. Most of the purchases are as cherry. Where both cherry and buni are purchased, the buni is processed separately from the cherry. Purchasing is either at the mill or at buying centres throughout the area served by the mill. Usually the grower receives a percentage of the value of his produce with the balance being

paid at the end of the season. One such system in Costa Rica was said to operate as follows :—

The grower is paid 50 per cent. of the value at selling time. At the end of the season, when the average green coffee price obtained by the mill for the season is calculated, the grower is paid the balance on a 6 : 1 ratio of cherry to green coffee.

Before the final payment, the following charges are levied against each supplier and deducted from his balance of payment :

(i) 5 per cent. government tax ;

(ii) 9 per cent. for the coffee mill. (The maximum profit allowable to the mill is fixed by law at nine per cent.);

(iii) A small charge is also made for processing.

After pulping and fermentation, the coffee is washed by passing it through centrifugal pumps and concrete water channels, which deliver it to extensive concrete drying barbecues. The wet beans are delivered from the water channels to the barbecues by mobile screw-conveyor units, which discharge large amounts of wet coffee on to the barbecues, quickly and simply. Before the introduction of these units, a greater amount of handling and more time were involved in moving coffee to and from the barbecues.

Once delivered to the large concrete barbecues, the coffee is either spread by workers using wooden levellers, or by a mechanical spreader. The latter machine was introduced fairly recently, is very effective and is expected to replace manual spreading, wherever the barbecues are large enough to warrant its use. The mechanical spreader is powered by a small petrol motor and has a six-foot spreading blade, not unlike a miniature bulldozer blade. Coffee can be spread to any desired layer thickness simply by adjusting the height of the blade, which is protected by rubber on its bottom edge. The machine moves on four broad rubber tyres without damage to the spread coffee. One mechanical spreader can easily cope with all the coffee on one barbecue.

When the coffee is to be moved from the barbecues, the spreaders move it into long heaped rows from which it is quickly bagged by the use of a mobile screw-conveyor.

No permanent covering is provided for the barbecues. Instead, waterproof tarpaulins are thrown over the coffee when required. A slight slope of the drying surface, from the centre of the barbecue, facilitates a quick run-off of moisture.

PLATE 6.—*Mobile screw-conveying unit delivering wet beans on to concrete drying barbecues at a modern coffee factory in Costa Rica.*

Both sun-drying and hot-air drying facilities are provided by the central mills. Rotary type hot-air driers are commonly used, although the American type tower-driers are gaining in popularity. Oil-fired driers are sometimes used, but more often the fuel used for the driers is either pressed pulp, parchment or buni husks, or prunings from shade trees.

Within the mills, spiral conveyors are very efficient in moving the coffee. After passing through the hullers, the coffee is passed through shaking-type grading screens. After being graded for size and shape, it passes on to air-pickers. Finally the high grades are hand-sorted on broad conveyor belts for discoloured and misshapen beans. Coffee destined for the European market, particularly Germany, is very carefully graded for size, shape and colour. In Hawaii an electronic eye separator, which separates for colour, is both very efficient and very expensive.

Grading and Marketing

The sale of green coffee is accomplished through an exporter who is a mill-owner and usually a grower. Various systems of payment operate for payments to the numerous growers supplying coffee to the mill. It is not unusual for mill-owners to advance money to growers.

From the exporter, the green coffee passes to the New York Market, to one of the other entry ports in the United States of America, or to one of the European markets of London, Le Havre, Hamburg or Antwerp.

It is of interest to note the system of grading adopted by the United States of America, the world's leading coffee consumer. Firstly, all green coffees imported into the United States of America are classified into either Brazils or Milds. Brazils comprise those coffees produced anywhere in Brazil. Milds include all coffees grown elsewhere. Both the Brazils and Milds are not only identified by the country in which they are produced, such as Colombians, Salvadors or Mexicans, but also by districts or states within the country or port through which they are shipped. The New York Coffee and Sugar Exchange Inc. determines coffee grades by comparison with standard types as adopted by the Exchange. There are seven of these standards, No. 2 to No. 8. No. 2 is the highest grade. For the placing of future contracts, the Exchange stipulates that No. 6 is the lowest grade deliverable.

In determining the number of a type, the coffee is graded by the number of imperfections contained in it. In general the various kinds of imperfections are black beans, stinkers, broken beans, shells, immature beans ("quakers"), stones and other foreign material. For counting the number of imperfections, the black bean has been taken as the basis, and all imperfections, no matter what they may be, are calculated in terms of black beans as follows :—

3 shells equal 1 black bean.

5 quakers equal 1 black bean.

5 broken beans equal 1 black bean.

1 small pod equals 1 black bean.

1 large pod equals 2 black beans.

1 medium stone equals 1 black bean.

2 small stones equal 1 black bean.

1 large stone equals 2 or 3 black beans.

The test is made on one pound samples.

By this scale a coffee containing no imperfections would be classified as type No. 1, but the possibility of this occurring is rather remote. The samples are graded as follows :—

6 black beans	No. 2.
13 black beans	No. 3.
29 black beans	No. 4.
60 black beans	No. 5.
115 black beans	No. 6.

(or equivalent imperfections.)

Types No. 7 and No. 8, containing more than 115 black beans, are graded by comparison with recognized Exchange types. Coffees graded lower than No. 8 are not admitted into the country.

Summary

Coffee production in a number of the countries discussed above is of major importance to their economies. El Salvador and Guatemala have a monocultural economy, as they are almost solely dependent on the coffee crop. In Costa Rica and Mexico, bananas and cotton respectively are the major crops although coffee still ranks high. For Jamaica, Puerto Rico and Hawaii, sugar and other crops eclipse the national importance of coffee. Of recent years, the industry has had to adjust itself to contend with fluctuating markets, outside competition and rising production costs. To a greater or lesser degree,

techniques have been and are being introduced to meet these exigencies. Broadly, these include.:—

(i) The concentration of processing equipment into large central processing mills.

(ii) Adoption of production techniques designed to reduce the number of labour units required per unit area. These include :

(*a*) Closer tree spacing to decrease weed competition and reduce the amount of pruning required.

(*b*) The use of multi-stem pruning systems in preference to single-stem.

(*c*) The increasing use of herbicides for weed control.

(*d*) Reduction of the number of pickings per season.

(iii) Increased yields by decreasing shade and increasing the rate of fertilizing.

(iv) Active experimental programmes, including varietal improvement, through selection and breeeding.

By these means the coffee industry is gearing itself to a minimum of manual labour. Although the principal aim is to reduce production costs to a minimum, producers are also ensuring that yields do not decrease and that coffee quality is maintained.

AGRICULTURE AND POPULATION IN THE MORTLOCK ISLANDS

A. D. Boag and R. E. Curtis.*

The writers describe the growing population pressure and unique agricultural system of one of the loneliest groups of islands in the Territory of Papua and New Guinea. They point out that the small island population is likely to double by 1970, *but say that more efficient use of the limited agricultural land for subsistence gardening, coupled with rat control and water conservation measures, should ensure the support of the increased population. An interesting sidelight is the description of the introduction of a new method of growing taro (Colocasia), which has resulted in a greatly increased output.*

Part I.—The Geographical Background

THE Mortlock Islands are a low coral group about 170 miles east-north-east of Bougainville and four degrees south of the Equator. There are eleven named islands arranged around the circumference of a lagoon, about eight miles across. A ring of reef surrounds the atolls, giving them some protection from the open sea and wind. The Mortlocks are more sheltered than the neighbouring Cartaret Islands, which are severely windswept and are sometimes inundated.

On the Mortlocks, sandy loam soils have built up and these have a poor to fair humus content. There is a freshwater lens at slightly above sea-level.

The village area for the group is on Nukatoa Island, while the principal subsistence food, taro, is grown mainly on Taku Island, in an 85-acre swamp.

The People

The people are of Polynesian origin and have inter-married in some cases with Melanesian pre-war immigrants.

The result is a pleasing, predominantly Polynesian type of fine stature and apparently happy disposition. Family groups are exceptionally large and healthy children abound.

When visited, the village was beautifully tended. The people were well-dressed in colourful lap-laps and their carriage and attitude offered a refreshing change from Melanesian drabness. Not one physical imperfection was observed in the whole population, but one youth is insane and one man blind, both afflicted after birth. Infanticide was practised up to two years ago and is probably the reason for such perfection.

Land Tenure

Little investigation was carried out in this sphere but ultimate ownership is believed to be communal under the leadership of the Tereki who is King. The Tereki in this case is Peo—also the Luluai. The Tereki is assisted by the Teburin or Tultul. The patrol was assured that land disputes were unheard of. Usually the Tereki conducted the business on the people's behalf.

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* The authors are the District Agricultural Officer and Agricultural Officer at Bougainville. This article was compiled from two departmental reports, the first made by Mr. Curtis following a preliminary visit to the Mortlocks and neighbouring groups in 1957 and the second by Mr. Boag a year later.

The first part is drawn mainly from Mr. Curtis' report, which went into considerable detail about the geographical and population background of the Mortlocks and other islands, and also pointed out the probability of a population pressure problem. The second part comes from Mr. Boag's report, written after he carried out the detailed agricultural investigation of the island.

In presenting this article, the Editor of the *Papua and New Guinea Agricultural Journal* hopes that contributions of this kind will be a regular feature of subsequent issues. It is planned to print a number of agricultural patrol reports which, over a period, will build up a picture of the agricultural variety of the Territory of Papua and New Guinea.

Customs

The people have their own religion and associated rites for all occasions. Ratu is the god who lives in their midst and controls all things. He is assisted by a number of lesser, however quite efficient, gods who control the people's everyday lives. Pukena is the god of tambus and troubles, including pregnancy, and Fakeva is the god of water in all places.

It is probable that there is an agricultural god and future patrols would do well to make the relevant inquiries and make their plans accordingly. For example, the people were told to mulch their gardens with plant and fish remains during this patrol. By virtue of different tambus on various persons this may be impossible for a few—fish remains have to be returned to the sea, the use of seaweed may be forbidden to some and so on.

The living standard seems to be high with little evidence of European influence, although the demand for money is there. Their culture is apparent in their houses which are pandanus-roofed, coconut-walled oblong buildings. The interiors are orderly and clean, and are crammed with plaited coir rope, fish lines, carved chairs, mats and other articles of everyday life. Sing-sings or dances are impromptu, with hula-style dancing and singing.

Population

1950—274.	1954—305.
1952—294.	1955—321.
1953—305.	1956—338.

1957—356.

The population had an increase of 5.3 per cent. in 1956-1957 period and an increase of 21 per cent. over the last five years.

Should the present rate of increase continue, the population will be doubled in or around 1970. A more intense and specialized system of agriculture could probably carry the additional population if the present climatic conditions continue and the pests and rodents are eradicated.

Part II.—AGRICULTURAL SURVEY

The principal purpose of the second patrol, agriculturally, was to determine the subsistence position in relationship to the present and future needs of the people. To facilitate matters, each of the more important crops to the subsistence economy of the islands will be dealt with separately.

(1) *Swamp Taro.* (*Cyrtosperma chamissonis*) (*Mortlock*—" Tepuraka ". *West Polynesian*—" Puraka ".)

Swamp taro is by far the most important food crop of the Mortlock Islanders. Cultivation of the crop is carried out on one island only, Taku, which has an overall area of approximately 175 acres and of which 85 acres is taken up by the swamp area, where *Cyrtosperma* is cultivated.

The *Cyrtosperma* pits in use to-day are those which were constructed by the ancestors of the islanders when the atoll group was first settled and have been in constant use since that time. The cultivation of the *Cyrtosperma* in the main garden area is purely a man's work and fragmentation of plot ownership is much in evidence, with each adult male controlling one, two, three or more plots widely scattered throughout the swamp area. The patrilineal inheritance of land is rigidly controlled and land cannot pass from one clan to another.

It is estimated that of the 85 acres within the swamp area, 15 acres are taken up by tracks for access. In the main these access tracks through the swamp follow the lines of heaped-up material which were thrown up during the initial construction of the pits. These also serve as division boundaries for clan and family plots and usually range from six to eight feet in height and 18 to 24 feet in width at their base.

Some instances were noted where the family plots had been recently extended by cutting into the division banks. The bringing into use of a further *Cyrtosperma* pit is customary in some families with the birth of a boy. By the time the boy has attained adulthood the new pit has weathered and is in a satisfactory condition to support the taro. However, the practice is limited and would appear to be reserved to celebrate the male birth.

The planting of *Cyrtosperma* is by suckers which develop from the base of the parent plant during the third year, or by replanting the top of the harvested plant. Planting is carried out along the edges of two to three feet deep pits or channels which are dug within the main pit area to gain direct access to the fresh water lens (see sketch).

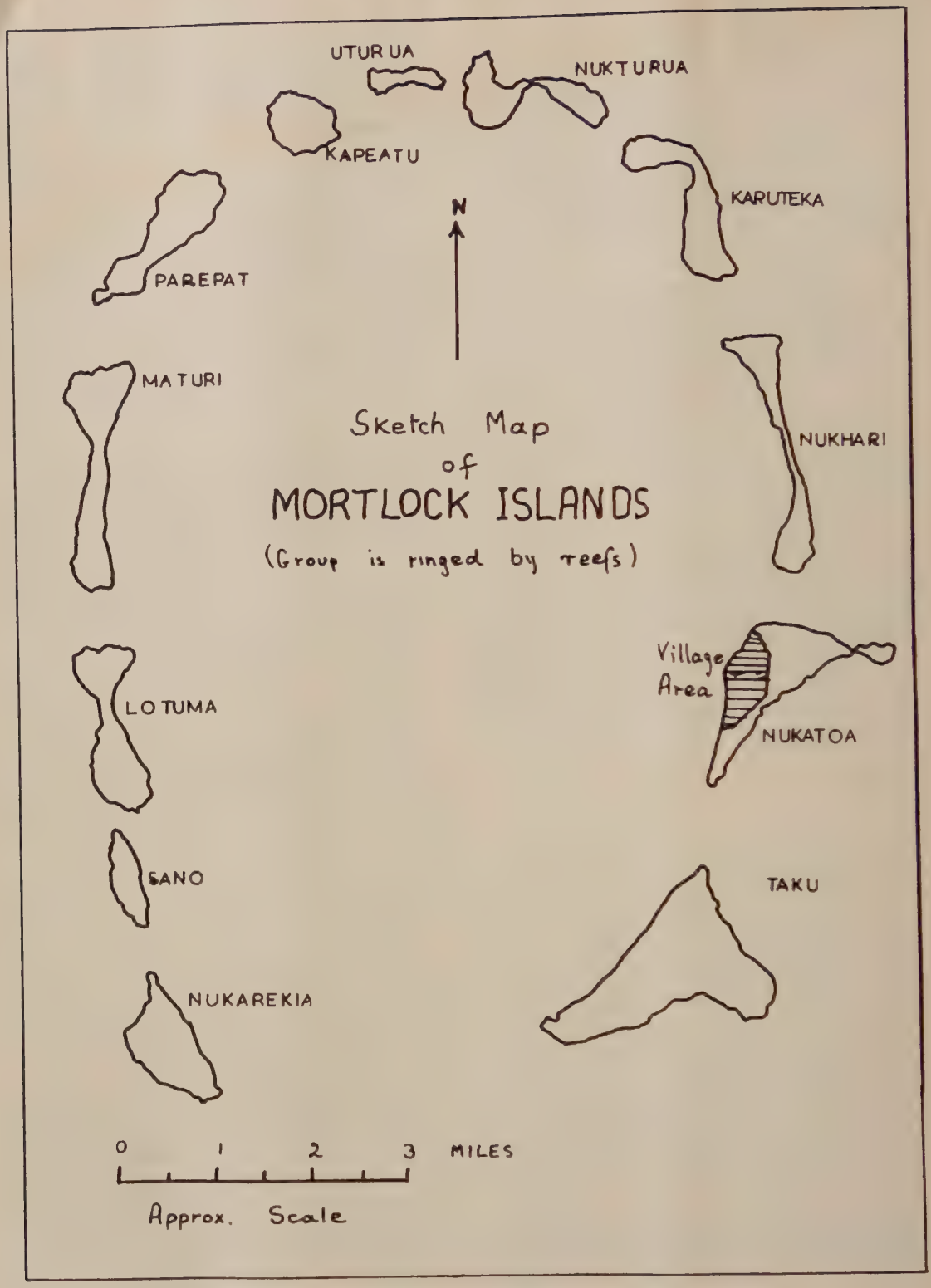

FIG. 1.—*Sketch map.*

Propagation by the first method produces harvestable plants in $3\frac{1}{2}$ to 4 years whilst propagation by the second results in plants being ready for lifting at three years.

As each plant is harvested, the vacated hole is immediately replanted but no attention is given the new plant until it commences growth, when it receives regular applications of leaf mulch. From the islanders' point of view, the purpose of leaf mulch is merely to protect the soil around the young plant from the heat of the sun and keep the soil cool. The more mulch, the cooler the soil and the better the *Cyrtosperma,* in the view of the people.

The fact that mulching also fertilizes the soil and provides the essential plant nutrients is apparently not appreciated by the people.

Leaf material for mulching is taken mainly from a broad-leafed tree of unknown species which is propagated throughout the coconut area for the above purpose. No use is made of a creeping legume observed growing on the beach just above high water mark nor of the few *Erythrina* trees present. Education in the use of all vegetative matter for mulching could do much to improve the productivity of the *Cyrtosperma* plots.

It was noted in many of the plots inspected, that the few marginal rows of *Cyrtosperma* were of considerable age and had received added attention. These plants are apparently reserved for some special occasion whilst the central plot area supplies the bulk of the food. With considerable numbers of plants of five to nine years of age present in the plots, it would appear that the need for more intensification of cultivation has not arisen and that sufficient *Cyrtosperma* is available for all.

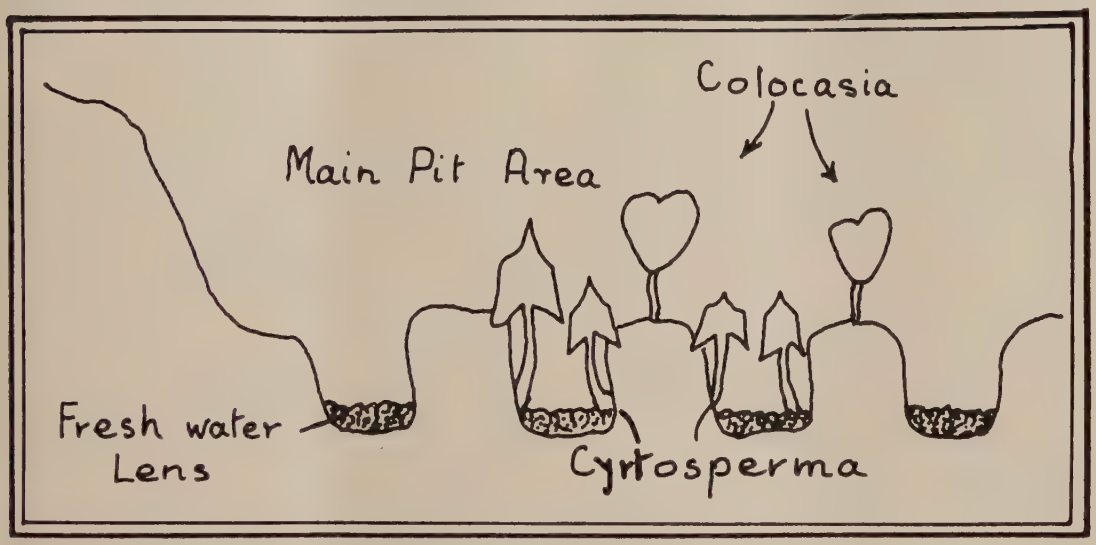

FIG. 2.—*Taro cultivation diagram.*

It can thus be appreciated that tuber size and rapidity of growth of the plants are determined by the amount of work expended in tending the plants and that the amount of food that can be produced is dependent on the industriousness of the individual. Great pride is attached to the growing of *Cyrtosperma* and a competitive spirit prevails, where each and every individual strives to produce the biggest and best tubers in a given period. Should one individual produce tubers of a larger size than normal, a precedent is set which everyone endeavours to attain. Social standing in the island is determined to a great extent by the size of tubers one is able to produce.

It is thought that the overall population could safely double itself before any undue pressure of overpopulation was felt. However, although in theory it would appear that the future position regarding the availability of land for *Cyrtosperma* is satisfactory when considered for the whole population, it is probable that a few individuals will be short of swamp land for the crop.

This situation, where a few individuals are short of swamp land, is in evidence now, but no undue concern is displayed over the matter as other crops can be cultivated outside the swamp area. More intensive methods of cultivation could do much to alleviate the position in regard to those whose clan land has been subdivided into progressively smaller units over the years.

(2) *Colocasia Taro* (*Colocasia esculenta*)

Until recently, the cultivation of *Colocasia* has, traditionally, been attended to by the women. A small area of approximately seven acres is set aside within the swamp, where the women tend their *Colocasia*. Being taro, the people naturally considered that similar conditions as those for *Cyrtosperma* were necessary for its growth. As a consequence, growth was generally retarded and tuber development restricted because the plants were planted directly into water. It was only during the periods of dry weather, when the water table receded and the ground dried out a little, that reasonable growth resulted. As the effort expended produced poor returns in terms of food *Colocasia* cultivation was considered unworthy of male attention and was left to the women.

However, within the past two years, a method of cultivation new to the islanders has been tried out with good results and was first put into practice by an islander who had visited other centres and observed *Colocasia* cultivation.

The *Colocasia* is planted along the raised intervals between the *Cyrtosperma* pits or rows (see sketch) and successful crops have resulted. The usual procedure is for taro planting to follow along behind in areas of harvested *Cyrtosperma* as the young replanted *Cyrtosperma* leaves do not produce any shade problems. From the third year of growth of the *Cyrtosperma*, the large leaves shade out the intervals and prevent further planting of *Colocasia*.

However, with judicious mulching, good quality *Colocasia* tubers are produced and the practice is becoming generally accepted.

If mulching is continued and the intervals are allowed a year or two to lie fallow, the practice should do much to increase the productivity of the gardens and ensure an item of food much relished by the people. It is somewhat difficult to assess the proportion of requirements that is supplied by taro but it is considered that once the above practice is firmly established, a fifth to a quarter of food requirements could come from this source.

It was noted that, since the realization that *Colocasia* will grow much more satisfactorily in drier soil conditions than those of the swamp area, cultivation of the crop is commencing in the coconut fringe. The few plots of *Colocasia* in this area exhibited normal growth and would undoubtedly produce well in these soil conditions, previously considered suitable only for *Xanthosoma* and *Alocasia* taros, yams and the few plants of Polynesian arrowroot (*Tacca leontopetaloides*).

With this area being available for *Colocasia* the cultivation of the crop should, over the next few years, considerably increase and become of more importance to the subsistence economy.

(3) *Yam* (*Dioscorea esculenta*)

(*Mortlock*—"Taufi". *West Polynesian*—"Ufi Lei".)

The extent of yam cultivation varies considerably with the individual family's desire for such food. The number of vines owned by each male varies from three or four up to 40, so it can be seen in some families, particularly those with less *Cyrtosperma* land that others, yams provide an important proportion of the food requirements.

Cultivation of the vines takes place along the drier banks of heaped-up material throughout the coconut area, and on the smaller islands of the group namely Karuteke, Farefatu and Lotuma.

Preparation of the selected spot prior to planting entails the removal of the soil and filling of the hole with leaf mulch and top soil gathered from beneath trees. The vines are supported by nearby saplings and are harvested as such food is required. No organized storage of the tubers is practised as they can remain in the ground for two to three years and are harvested as required.

Within the families who experience a shortage of *Cyrtosperma*, the proportion of the annual requirements supplied by yams would probably be in the vicinity of 25 per cent. If the need arose, much more intensive cultivation of the crop could be carried out, particularly along the division banks as only isolated vines were noted during the course of inspection of the *Cyrtosperma* pits.

(4) *Coconut.* (*Cocos nucifera*)
(*Mortlock*—"Tenui". *West Polynesian*—"Nui".)

The coconut, as elsewhere in island subsistence agriculture, commands a place of considerable importance in the subsistence of the Mortlocks. The palm is present on all islands of the group with the greatest concentration being on the main garden island, Taku. Here, most of the approximately 90 acres outside the swamp area has been planted to palms, the planting being carried out during the German Administration.

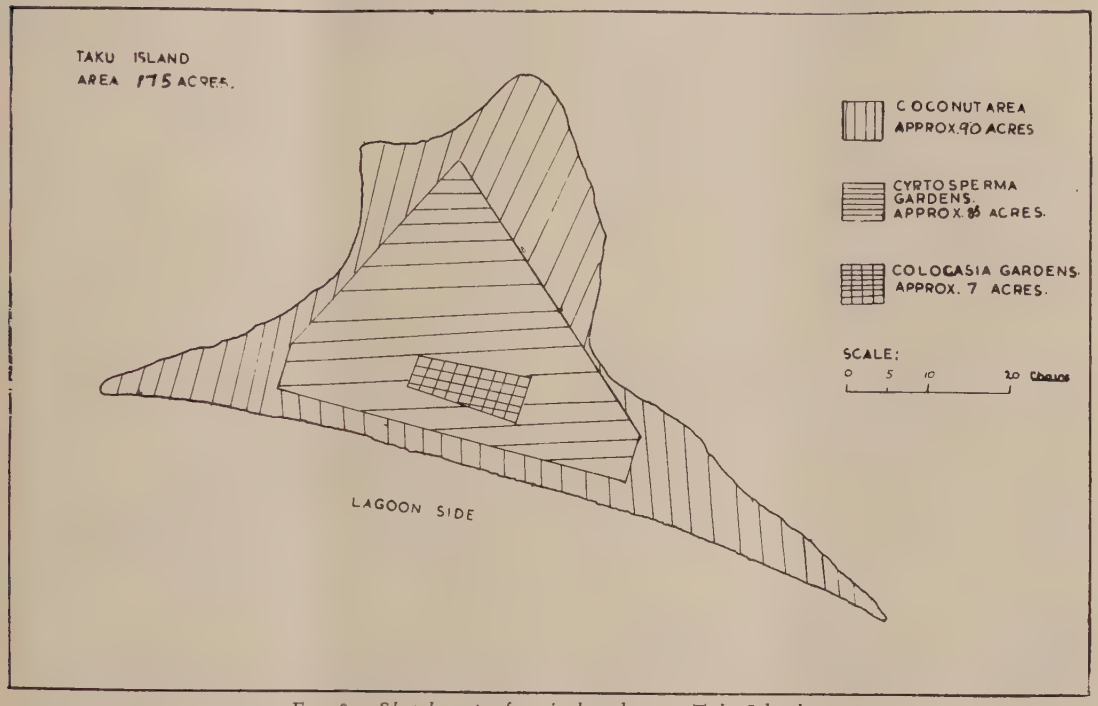

FIG. 3.—*Sketch map of agricultural areas, Taku Island.*

An exceedingly large number of nuts is used daily for the preparation of coconut "cream" which is an essential ingredient in the cooking of *Cyrtosperma.* Each household also has a considerable store of germinated nuts for use by the aged and infirm and for young children. The coconut "apple" of the germinated nut is the portion used.

The use of the immature nut or "Kulau" for drinking purposes, is not as greatly practised as it might be considered for an atoll where water problems usually exist. The people depend, when possible, upon rain water caught in drums under a few sheets of iron or under coconut palms. It is only during the periods of dry weather that the people have to make use of large numbers of "Kulaus" for the provision of drinking and cooking water.

The recommended provision of a large galvanized iron catchment area with tank storage facilities would greatly benefit the people by providing, in a normal year, a plentiful supply of good water and by allowing more coconuts to reach maturity for eventual use as food or as copra.

On the home island of Nukutoa, each household has one or two palms reserved for the sole purpose of "toddy" collection. It is either used fresh as a beverage or it is concentrated over a slow fire for the production of a molasses. Little evidence was noted where the "toddy" was allowed to ferment to produce an intoxicating drink.

(5) *Subsistence Crops of Minor Importance*
(*a*) *"Konkon" taro.* (*Xanthosoma* sp.)

Small plots of *Xanthosoma* taro were noted throughout the coconut area on Taku, but the crop is usually only cultivated as a standby in

case of any minor *Cyrtosperma* failure, and to provide the occasional meal by way of a change of diet.

(*b*) *Alocasia* spp.

(*Mortlock*—" Tekape ". *Polynesian*—" Kape ".)

Similar uses as for *Xanthosoma* but less used due to the requirement of special cooking preparations to remove oxalate crystals.

(*c*) *Breadfruit.* (*Artocarpus altilis*). Seedless var.

(*Mortlock*—" Tekuru ". *Polynesian*—" Kuru ".)

The breadfruit tree is not in abundance and the fruit is eaten as it ripens. No effort is made to preserve any excess to immediate requirements. It is probable that the proportion of the usual staples used during the season of breadfruit production is reduced, but it is only of minor importance.

(*d*) *Pandanus.* (*Pandanus tectorius*)

(*Mortlock*—" Tefara ". *Polynesian*—" Fara ".)

The mature fruit of the pandanus is eaten in its raw state, the yellow fleshy fruit base of each segment being the portion eaten. The fruit is eaten considerably during the season and its slight sweetness of juice is relished. However, it is of little importance to the actual subsistence of the islanders, except for its carotine content, and it is merely utilized as a fruit.

(*e*) *Papaw.* (*Carica papaya*).

The papaw tree was noted throughout the coconut area of Taku and on the home island. The fruit is utilized in its green state as a vegetable and as a fruit, if harvested at first signs of ripening. If allowed to remain too long on the tree, the fruit is quickly destroyed by rats. The papaw has some prominence in the subsistence of those families who have a slight shortage of swamp land for *Cyrtosperma.*

(*f*) *Banana.* (*Musa* spp.)

The banana is cultivated on the five main islands of the group, namely Taku, Nukutoa, Karuteke, Farefatu and Lotuma. Both the cooking and common eating varieties are present, the former being used for the occasional change of diet and the latter as a fresh fruit.

(*g*) *Polynesian Arrowroot.* (*Tacca leontopetaloides*).

(*Mortlock*—" Piakere ". *Polynesian*—" Pia ".)

This plant was evident in scattered plots throughout the coconut area on Taku, but is generally not seriously cultivated. It is harvested for its starch for the occasional meal, but generally the work involved in reducing the starch to an edible condition rules it out as being a crop of any great importance. However, when the starch is prepared, it is mixed with grated coconut for the baking of cakes, which are mainly used as food for children. The prepared starch is known locally as " Tepia ".

Before summarizing the present and future subsistence position of the islands, the rat problem will be considered, as this problem undoubtedly has a considerable bearing upon the general subsistence economy.

The Rat Problem

The rat problem exists, in varying degrees, on all islands of the group, with the greatest concentration occurring on the main garden island of Taku. Here, it was noted that considerable numbers of rats were out searching for food even during the day. It would be difficult to assess the damage caused to crops, but the rats would undoubtedly cause considerable loss in productivity from such crops as *Colocasia* and *Cyrtosperma* taros and coconuts, whilst such crops as sweet potato cannot be grown because of excessive damage to the tubers. Control of the rat population would do much to increase the production of the main subsistence crops.

To achieve such control, baiting will be the only practical means, particularly on all islands except the home island of Nukutoa. Here, the introduction of cats seems to have effected control, principally because of its small size and the fact that it is inhabited. During the time the patrol was on the islands, a number of baits was laid out to test the degree of acceptance of the baits by the rats. The poison used for the preparation of the baits was A.N.T.U.

In the first instance, coconut meat was used as a base, with the powder being dusted on to the meat. Baits were readily taken and consumed within a short period during the day. In the second instance the powder was mixed with a grain mash, at the proportion of one to 20, and the prepared mixture distributed in paper bags.

As coconuts are plentiful, use will be made of these as a base for any poison when the programme for the control of the pest is put into practice.

General baiting would need to be carried out over the whole of the island and it is probable that 90 per cent. of the rats could be eradicated with the initial baiting. Periodic baiting after this should ensure control, if not complete eradication of the pest.

Any such scheme for the control of the rats will need to be carried out by the people themselves. Two islanders have been brought back to Sohano for instruction in the use of the poison, and will supervise the implementation of the scheme.

It is considered that the control of the rat would do much to step-up the production of subsistence crops, thereby assisting to alleviate the position of any food shortages for the population.

Summary

The following is a summary of the considered general subsistence position of the Mortlocks with recommendations for increase of production of the staples :—

(*a*) When considered as a whole, the population could double itself without undue pressure of our population being felt. However, as a few individual family units are short of land for *Cyrtosperma* cultivation, it would be well to consider such people for outside employment, if the restrictions of employment were partially relaxed. This would serve to relieve the pressure on such units and make available ample *Cyrtosperma* for those who remain.

(*b*) Better methods of *Colocasia* cultivation now being practised will do much to increase the proportion of requirements supplied by taro. *Colocasia* cultivation could be increased by those families short of swamp land for *Cyrtosperma.*

(*c*) Much more use could be made of the yam than is now being done. Cultivation of the crop could be greatly increased, particularly along the tracks throughout the swamp area and on the drier soils of the other smaller islands.

(*d*) Education in the use of all vegetative material for use as compost will be needed to ensure continued productivity of the limited arable land. As these people practise an intensive system of agriculture, it is considered that they will readily accept any proposed new cultural techniques.

(*e*) Control of the rat will be necessary to ensure fullest possible productivity of all crops.

(*f*) Control of the mosquito would indirectly increase production as more time could be spent in the gardens. This will be necessary if intensification of cultivation is to be possible.

(*g*) The provision of a large water catchment area will lead to a possible reduction in the utilization of "Kulaus" for drinking water, thus allowing more coconuts to reach maturity for eventual food or for copra production.

(*h*) Relaxation of the employment restrictions would do much to relieve any pressure of overpopulation and also help to reduce the high birth rate.

(*i*) Briefly, it is considered that there is definitely no present subsistence problem and that any such future problems that may occur can be overcome with the implementation of the above recommendations.

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COCONUT AGRONOMY—1954-1958

A. E. CHARLES.

Despite the importance of the copra industry to Papua and New Guinea, knowledge of some of the basic agronomic problems of the coconut still lags behind that of the other tree crops of the Territory. The author, the Coconut Agronomist at the Lowlands Agricultural Experiment Station, at Keravat, New Britain, explains that a survey of world coconut literature showed that this situation is international. In this article, Mr. Charles describes the new experimental programme which was undertaken after war damage was cleared up in Papua and New Guinea and the progress made since 1954. *The work has proceeded along two major lines—the improvement of existing palm stands and the development of improved seed for new plantings.*

DURING the Japanese occupation of Papua and New Guinea, the coconut plantations were left unattended for several years and many suffered damage from bombing and strafing during the hostilities. Consequently, the main task of plantation owners for some years after 1945 was the clearing of scrub growth and general renovation of plantations. However, during the period which this report refers to, increasing attention has been given to the improvement of plantations by the extension of the area planted, replanting old palms and interplanting with cacao.

Most of the experimental material and records of experiments of the Department of Agriculture were destroyed during the war. As a result, it was necessary to start again from the beginning with a new experimental programme.

Two approaches were considered—

(*a*) the improvement of existing palm stands ; and

(*b*) the provision of improved seed for new plantings.

Before concentrating on either approach, all available literature was surveyed so that full advantage could be taken of findings from other parts of the world. This survey was hampered by the fact that much of the literature was out of print and hard to obtain. However, sufficient was obtained to show that there has probably been less scientific study of the coconut than of any other crop plant of comparable importance and much work remains to be done, even on many of the basic agronomic problems.

With cultural practices, experiments in different parts of the world have shown responses to manuring with potash, phosphorus, nitrogen, lime and farmyard manure and yield improvements have also been obtained from ploughing and from forking the soil under certain conditions.

Regarding the provision of improved planting material, from the results of a critical experiment carried out in Ceylon, it seems highly probable that the traditional method of improvement of planting material is quite ineffective. This experiment showed that the use of seed from high-yielding mother palms gave no significant improvement, even where the mother palms had been selected after some years of careful observations. The same experiment showed, however, that improvement could definitely be achieved by nursery selection of seedlings.

The general conclusion from this literature survey was that genetic improvement of planting material would be a very long-term project. At the same time, it was apparent that the condition of existing stands in many parts of the Territory left much to be desired. Many of these are declining in productivity, as well as being of obviously unhealthy appearance. This condition is not usually wholly explicable by the old age of the stands, although old age is commonly a partial cause.

It was therefore decided that in the programme of coconut agronomy the work should be concentrated initially on the improvement of existing palm stands. At the same time, the

problem of providing improved seed has been given some attention and the first stages of a breeding programme have been commenced.

Personnel

Agronomist A. E. Charles was assigned to coconut work in February, 1954, and Agronomist P. L. Stallwood was appointed in November, 1957. Both these agronomists are based at the Lowlands Agricultural Experiment Station, Keravat. Much research work on coconuts has also been carried out by other officers of the Department, but this report will be restricted almost entirely to the work of the agronomists.

Surveys

Over the last four years, the coconut agronomist has visited plantations throughout most of the major producing areas in the Territory and impressions of palm condition in these areas are summarized below. Most of these visits have not taken the form of a detailed survey, as the amount of attention given to each area has been determined largely by the nature of the problems encountered.

A.—New Ireland

This is one of the main problem areas and has received first priority in the agronomy programme. However, the New Ireland work has already been fully described in this Journal (Vol. 11, No. 4) and no further reference will be made to it here.

B.—Papua

Although the general standard of plantations on the south coast of Papua is good, most of them have patches of poor-yielding palms. Experiments by British New Guinea Development Company had shown that some response could be obtained from fertilizing, so it was decided to make a survey of the area with a view to laying down critical trials.

In 1956, the coconut agronomist visited most of the plantations on the south coast of Papua between Hisiu Beach in the west and Mullins Harbour in the east. This covered an area of more that 13,000 acres of coconuts.

Two main soil types are found on these plantations. On the coast and extending to about half a mile inland are soils derived from black sands. These cover an area of about 4,500 acres. Typically the soil has a black, humic, loamy sand surface horizon, 6 to 12 inches deep, underlain by sand. Texture of the soil is usually fairly fine, but in patches it varies to a coarse sand and sometimes even to a coarse gravel. On one plantation, poor condition of palms appeared to be associated with coarseness of the parent material. On several plantations, there were patches of very poor palms planted on old grassland country, where repeated burning had no doubt exhausted most of the plant nutrients. However, palm stands generally on these soils are tall (60 to 80 feet) and healthy, yielding about half a ton of copra per acre per annum. Most of the palms are between 40 and 50 years old. There were also, on most plantations, patches of poorer-looking palms which could not be related to any obvious feature of the soil and it was considered that such an area would be a good location for a fertilizer trial.

A variation of this soil type found on two plantations has a black, sticky surface soil, probably due to formation under swamp conditions and a continuing tendency to waterlogging. Nevertheless palms are fairly healthy.

In the Hisiu Beach area, with annual rainfall of only 50 inches and a well-marked dry season, copra production fluctuates considerably, but this is almost certainly an effect of water relations rather than of nutrient supply.

The second major soil type is an alluvial brown loam, which makes up about 6,500 acres of the planted area. Typically this soil is a friable, well-drained brown loam, with no marked horizon differentiation, but a gradual paling in colour over the first 18 inches. There is a tendency for the soil texture to grow sandier with depth, and in some places the loam merges into a fine sand at about 24 inches depth.

Palms on this soil also are mostly about 40 to 50 years old, well-grown (60 to 80 feet and taller on some plantations) and productive. However, there are some large areas of poor palms on most of the plantations. It was considered probable that in many cases this was a result of poor drainage rather than nutrient deficiency as all the areas are flat and low-lying, so that drainage is quite a problem. In view of this observation, it was decided not to place a fertilizer trial on one of these poor patches, but to choose a more or less average stand of palms for the soil type.

There are other soil types on these plantations, but it was considered that the small areas involved did not warrant the laying down of detailed trials at this stage.

C.—Gazelle Peninsula

No detailed survey has been made of plantations in this area, but several have been visited by the coconut agronomist. The main problems in this area are entomological and will not be discussed here.

The main agronomic problem is senility. Some of the plantations are very old. However, as many of the older palms are still carrying good crops, there can be little doubt that the soils are good enough for the old palms to be replaced without any fertility problem. Many plantations have dense kunai (*Imperata*) ground cover, which cannot improve the soil and certainly does not help in the finding of nuts. However, establishment of leguminous cover crops is a problem because of the giant snail.

Very large areas of coconuts in the Gazelle Peninsula are interplanted with cacao and, where these have been adequately maintained, both crops are doing well. However, the drain on soil nutrients from two crops in full bearing must be heavy, and there are some indications of possible nutrient deficiency on interplanted cacao that has been bearing for several years. Consequently, a fertilizer trial has recently been commenced on one such area. There are minor areas on the Gazelle Peninsula where palms are not doing well, but as yet it has not been possible to make any detailed investigations.

D.—Bougainville

This area has not been surveyed in detail, but the coconut agronomist visited several plantations in 1954-55. Soil types were varied, including coral-derived, alluvial and volcanic soils. Apart from a few areas where water relations were obviously unfavourable, the general impression was that the plantations were doing well and that there were no problems requiring urgent attention.

E.—Madang District

Several plantations along the mainland coast between Madang and Dylup (a distance of 45 miles), and plantations on Karkar Island, were visited in 1956.

Most of the coastline plantation area is on soil developed over koranas (loose decaying coral), though there are some patches of alluvium and other soils. Rainfall ranges from 140 to 170 inches per annum. A typical plantation has a fairly flat strip along the coastline, 100 to 500 yards deep, and behind this ridges rise sharply, so that most of the plantation is rough country with steep gullies. Generally there is about 12 inches of black, friable loam overlying koranas. Where the soil is deeper the surface loam changes to a sticky clay at 15 to 18 inches depth. Palms on the flats are productive and look healthy, but in the back area the palms are variable and are usually poor on the steep slopes. The shallow soil and uneven relief probably provide an adequate explanation.

The general impression of this area was that the plantations are up to the Territory average particularly for coral-derived soils. There are not the same problems as in New Ireland as there appears to be little development of the deep acid clay soils on which the worst decline has occurred in New Ireland.

Karkar is an island of volcanic origin, about 10 miles in diameter and about 40 miles distant from Madang. There is a coastal fringe sloping gently down to the sea. The soil is uniform, loose and loamy with numerous fragments of stone. Rainfall is in the range of 150 to 200 inches. There are about 15 plantations around the island with a total area of about 4,000 to 5,000 acres.

According to figures given by plantation managers, the average yield is about 14 to 16 cwt./acre/annum. This high yield is largely attributable to the uniformity of bearing throughout the plantations. Individual palms carry a good, but not exceptional, number of nuts. Nut size also is more uniform than is usual in the Territory and nuts are also bigger than average, with a copra out-turn of about 4,500 to 4,800 nuts per ton. It is considered that few agronomic problems are likely to be encountered on this island.

F.—Markham District

This district was visited mainly for the study of the Markham type of palm, which will be discussed elsewhere. It is not an important coconut area, but two commercial plantations, a number of village groves and some new plant-

ings were visited. All these are on alluvial soils, which vary from sands to loams and coarse gravels. Palm-stands also vary. Some areas are very poor, although most are good. The variation is almost certainly related to the variation in soil texture, but because of the limited area concerned, other more important problems have taken precedence in the experimental programme. No detailed study has been made in this area.

IMPROVEMENT OF EXISTING STANDS—FIELD EXPERIMENTS

A. *Fertilizer Trials.*

1.—*Sole Coconuts*

Comprehensive fertilizer trials were laid down on coconut plantations in New Ireland in 1955 and in Papua in 1957. The former trials have already been described in detail in this journal (Vol. 11, No. 4).

The Papuan trials are slightly different from those in New Ireland. Gypsum has been used instead of lime as a source of calcium. The soils are not acid and lime is not needed to sweeten them. Details of fertilizers and rates of application are as follows :—

Fertilizer.	Amount per acre.
Gypsum	4 cwt.
Sulphate of ammonia	4 cwt.
Muriate of potash	2 cwt.
Disodium phosphate	2 cwt.
Magnesium sulphate	2 cwt.
Copper sulphate	14 lb.
Zinc sulphate	14 lb.
Sodium molybdate	1 lb.
Trace element mixture comprising—	
Sulphate of iron	56 lb.
Manganese sulphate	28 lb.
Cobalt sulphate	2 lb.
Borax	28 lb.

The rates given are for a dressing to be repeated at two-yearly intervals. However, the sulphate of ammonia is applied more frequently, at the rate of 1 cwt./acre every six months. The use of materials such as disodium phosphate is simply for the sake of experimental purity. In normal practice, superphosphate would probably be used.

The design of the trial is of a complex nature but is arranged so that the effects of all fertilizers, individually and in their important combinations, can be accurately assessed. A total of 128 palms is included in the trial and each receives a different fertilizer combination. The arrangement is such that, for instance, the effect of sulphate of ammonia is assessed by a comparison of the performance of 64 palms which received dressings of sulphate of ammonia with 64 which did not receive sulphate of ammonia. The same is true for each fertilizer tested. In technical terms, the design is a factorial, a quarter replicate of 2^9, with eight sub-blocks of 16 trees each.

Two of these trials have been commenced on typical examples of the two main soil types described :—

(*a*) *Black Sand.*

The area selected carried tall, well-grown palms, most of them producing well. However, many of the palms showed pronounced yellowing of the foliage, while on the same plantation there were patches of this soil where the palms were in an advanced state of decline. Initial yield of the area was estimated at about 11 cwt./acre/annum, with a copra out-turn of about 4,900 nuts/ton.

Fertilizer was applied in October, 1957. It is too early yet for any response to be definitely detected.

(*b*) *Alluvial Brown Loam.*

Palms on the site chosen were well grown and healthy in appearance, as was typical on this type of soil. Initial yield of the area was estimated at about 12 cwt./acre/annum, with copra out-turn of about 5,200 nuts/ton.

Fertilizer was applied in March, 1957, but as yet there are no clear indications of response to any treatment. Comparing this result with that of the trial in New Ireland on yellow-brown clay, where a response to potash showed quite clearly after 18 months, it appears likely that there are no major deficiencies in this type of soil. Further yield records will be necessary to confirm this.

2.—*Coconuts Interplanted with Cacao*

As has already been stated, a trial is being carried out in the Gazelle Peninsula on a stand of mature cacao (10 years old) interplanted under coconuts, with no additional permanent shade.

The fertile soils of this area are normally well supplied with plant nutrients. However, an experiment on sole cacao at Keravat showed a

slight response to nitrogen and it is considered likely that any deficiency of this element would be accentuated under interplanting conditions, where there is no legume cover crop or shade tree. Chemical analysis of the soil also suggests that phosphorus could be low. Consequently both nitrogen (as sulphate of ammonia) and phosphorous (as superphosphate) have been used in this trial. Sulphate of ammonia was applied at two rates (1 and 2 cwt./acre/annum) and superphosphate at one rate (1 cwt./acre/annum).

The design of the trial is a 2 by 3 factorial with three replications. Plot size is nominally 16 coconut palms (4 by 4) but several palms are missing and spacing is somewhat irregular in places. Hence the actual number of palms a plot averages only 12.5. The numbers of cacao trees are also variable, ranging from 40 to 52.

Preliminary yield recording (counting of nuts on the palms as six-monthly intervals and counting cacao pods at each harvest) was commenced in January, 1958, and the fertilizer was applied in August. Some results may be evident, at least in respect of cacao yields, within the next 12 months.

B. Cultivation Trials.

The practice of cultivation in coconut plantations has never appealed to Territory planters, although there have been some definite reports from overseas of benefits from the practice. One good reason for the lack of interest in this country is the fear that under the high rainfall conditions in most areas the soil would become vulnerable to erosion.

Since in most soils the bulk of the palm's roots are to be found close to the surface, there can be little doubt that intensive cultivation, whatever its long-term results, would severely set back the palm at first by cutting a large proportion of its roots. Two treatments were therefore used in experiments—strip ploughing and disc harrowing. Strips 10 to 15 feet wide were ploughed down the centre of alternate rows and the treatment was repeated as yearly intervals, alternating the rows which were worked. This treatment should have achieved the moderate "root pruning" which some authorities claimed to be beneficial. The aim of the disc harrowing was simply to break up any surface crust on the soil and to turn the cover crop in as a green manure. This treatment was repeated every six months.

One such trial, laid down in New Ireland in 1956, has already been described in this Journal (Vol. 11, No. 4). A similar trial was commenced on the Government Plantation at Baibara, Papua, in March, 1957. This trial is located on a typical brown alluvial loam soil. Cattle are grazed in the area, which has a predominantly grass cover. As there is both a lighter soil and a lighter cover crop, the operations have been more successful than in New Ireland. Ploughing has been satisfactory, but the harrows do little more than scratch the surface. It has been noticed, however, that kunai (*Imperata*) grass, which previously was scattered through the area, has been very much reduced by the harrowing.

On this experiment, the nuts are being collected and counted after falling, instead of on the palms. Consequently any response to the treatments will be slower in showing up. Analysis of yield records up to October, 1958, shows no response evident as yet. Yield in the first 12 months was about 12 cwt./acre.

C. Maintenance Trial.

This trial, located at Baibara, is designed to assess the comparative costs of three different methods of cover maintenance, as well as to observe how effective each method is from the point of view of finding nuts and of eliminating undesirable plant species.

The three methods compared are cattle grazing, tractor and drag, and handslashing (this last being the most common method used through most of the Territory). Each method is being tested on blocks of approximately 35 acres.

The original cover was a dense mixture of grasses, mainly kunai (*Imperata*), thurston (*Paspalum conjugatum*), couch (*Cynodon sp.*) and *Paspalum paniculatum*; sensitive plant (*Mimosa pudica*); "clover" (*Desmodium heterophyllum*); *Centrosema pubescens* and scattered clumps of fern. Some changes in the botanical composition have occurred under the different treatments.

Cattle grazing has reduced the *Imperata* and *Paspalum paniculatum* but the amount of fern has increased. With dragging, the *P. paniculatum* has greatly increased and in patches it completely dominates the other grasses, while *Centrosema* has also become more prominent in other places. The handslashing has caused little change, although there may have been some increase again in *P. paniculatum*.

Concerning effectiveness of the treatments, cattle grazing, if sufficiently intense, will keep the pasture very short so that nuts can be found with the greatest of ease. However, the bulk of pasture growth is much greater in the wet season than in the dry, so that the number of cattle which could be carried in the dry season would not be able to handle the wet season flush of growth. It would probably, therefore, be essential to cut the cover by hand or machine at least once a year. The drag also helps in finding nuts, as it collects all that lie in its path and carries them along for some distance before finally lifting over them and leaving them in a heap. However, there appears to be some tendency for the building up of a dense mat of organic matter on the surface which is very slow to decompose.

Costing of grass maintenance by cattle grazing is fairly complicated and has not yet been calculated. Handslashing, with the usual task of 40 rooms per labourer per day, costs 8s. to 10s. per acre per operation. Cost of dragging at Baibara varies from about 7s. to 12s. per acre per operation, depending on weather conditions, as control of this type of cover requires the use of a heavy drag (a heavy hardwood log squared and faced with angle iron on the leading edge). When the ground is wet and sticky the operation is inefficient. Thus on Baibara cost of mechanical maintenance is similar to that of handslashing, since both operations need to be repeated at about the same intervals. It may be noted, however, that on plantations with a good legume cover crop, a lighter drag would give satisfactory control and thus lower costs.

D. Replanting Trial.

Some Territory plantations have now reached the stage where productivity is declining because of old age, and many more are approaching that stage. Consequently, if overall productivity is to be maintained, many old stands will have to be replanted within the next 10 to 20 years.

In an attempt to minimize costs of replanting, a technique is being used in Ceylon where some of the old palms are left standing until the replants come into bearing. As yet no very definite results have been published on this work and in any case labour conditions are so different in Ceylon that their findings would not apply directly to the Territory.

Consequently, experiments are being commenced to determine the usefulness of this system for our local conditions. The method is to plant seedlings in the centre of the rooms between the old palms and to thin out the old palms to some extent to allow light to enter and to reduce root competition. In the experiment, different degrees of thinning are being used with the following proportion of palms being removed—0, 25, 50, 75 and 100 per cent. To gain accurate results a large area has to be used. The trial involves a block of 2,000 palms, of which approximately 1,000 have been cut out. The trial is a simple randomized block design, with four replications of the five treatments. Plot size is 36 palms (6 by 6) with a double guard row receiving the same treatment, thus bringing the plots to 10 by 10.

The trial was marked out at Baibara in April, 1958. Yield records are to be kept of some palms in all plots, as it is anticipated that there will be some increase in yield of the remaining palms where the stand has been thinned and this should compensate to some extent for the reduction of palm numbers. Felling of the old palms and planting of the new seedlings was carried out in September-October, 1958. Final results from this trial will probably not be obtained for at least ten years, but it is anticipated that differences in growth rate of the seedlings under different levels of thinning will show up quite early.

One point which already emerges from this trial is that by far the greatest expense in the replanting programme comes from the cost of disposal of the old palms. These must, of course, be destroyed or they will provide breeding sites for insect pests. The palm trunk does not burn readily and has to be cut into lengths, split and stacked to dry before it can readily be disposed of. This is likely to prove almost as expensive as the clearing of virgin bush, and planters might be well advised to consider carrying out replanting over a long period and offsetting these costs by using the palm trunks as drier fuel

A similar type of trial, but on a smaller scale, is being carried out in New Ireland, the area having been marked out in June, 1958. The palms on this site are not as healthy as those at Baibara, and therefore do not throw so dense a shade. It is to be expected, therefore, that

the two trials will give somewhat different results, but together they should provide information applicable to most types of palm stands in the Territory.

E. Interplanting Trial.

In 1955, an experiment was commenced at Keravat to compare the costs of establishment of sole cacao, cacao interplanted under coconuts and sole coconuts. Ultimately the trial would also show the comparative returns from the two crops grown separately and in conjunction.

For interplanting, it is essential that the coconuts be well established before the cacao is planted, otherwise the palms would be shaded out by the quicker-growing *Leucaena.* In addition it is desirable to have the coconuts provide a large portion of the shade for the cacao. The actual stage at which interplanting could be commenced would be judged as the trial proceeded, but the coconuts would probably need four to five years' start.

The experiment has been unsuccessful, however, in its first aim at least, because of the very heavy rhinoceros beetle (*Oryctes rhinoceros*) population in this particular locality. Despite daily inspection of the seedlings and insecticidal treatments, a high proportion of the seedlings was killed in the early stages and most of the rest have been severely set back. However, in the last 12 months, those palms which survived the first two years have come away fairly well, and new methods of insecticidal treatment give promise of adequate control of the insect (though probably at costs which would be uneconomic for a commercial grower). The missing palms are being replaced, and it is hoped that the trial may eventually be established satisfactorily. However, the costs will bear no relation to normal expectations.

PROVISION OF IMPROVED PLANTING MATERIAL.

As stated in the introduction of this report, the results of an experiment in Ceylon discount the effectiveness of the traditional method of coconut improvement by mother palm selection. Some alternative method is therefore needed and after careful consideration it has been decided that the most effective approach is by progeny testing.

Progeny Trial

The reason why mother palm selection may be ineffective, is that the performance of a palm is dependent on many factors other than its inherent qualities. The environment in general probably has a considerable influence on the palm's performance as soil conditions and competition with surrounding palms are highly variable and a setback in the first few years of life (as by insect damage) probably influences the whole future performance of the palm. Consequently, palms which we select as high yielding probably owe their superiority to their environmental situation rather than to inherent factors. When it is also remembered that the male parentage of seed from selected palms is unknown, it is not surprising if this seed is only of average quality.

This is a similar problem to that faced by animal breeders and the most effective solution that has been devised is that of progeny testing. The merit of the parent is not judged from its own performance, but from the performance of a large number of its progeny. The same technique can be applied to coconuts, although the disadvantages are a longer waiting period for results and the fact that large areas of land are necessary, since 40 to 50 progeny palms must be used to give a reasonable assessment of the value of the parent. On the other hand there is the advantage of the longer life of the parent palm.

A trial was initiated at Baibara in April, 1957. Twenty palms of representative types, from a single block of the plantation, were marked, and detailed records of their performance are being kept so that it can ultimately be checked whether the parent yields do bear any relation to progeny yield. Nuts from these palms were planted in a nursery, and notes have been made of their germination and early growth. Already differences between progenies, probably inherent, have been observed at the germination stage. The average for the 20 progenies, up to May, 1959, was 77 per cent. germination, but individual progenies varied from 50 per cent. to 96 per cent. Of the 20, nine representative types were chosen for the actual trial. This number is small, but one may expect to find among them two or three above-average parents. The limitation on number is due to the area involved.

With nine progenies, the trial covers 11 acres, and anything larger than this might reduce too greatly the accuracy of the experiment, because of soil variability.

The design of the experiment is a 3 by 3 balanced lattice with four replications. Plots are of 12 palms (4 by 3). To reduce edge effects the trial area is surrounded by a single row of guard palms.

Half the seedlings in the trial were transplanted in May, 1958, but very dry weather in the months that followed set them back and nine per cent. had to be replaced in October. Continuing dry weather prevented the planting of the remaining half, but it is hoped soon to be able to complete planting.

The next step in the programme, after choice of the best parents, has not yet been decided. Obviously two or three palms will not provide enough seed to be of any direct benefit. However, the same inherent qualities are to be found in the pollen as in the nut, and it might be possible to use this to produce seed in moderate quantity by hand pollination. Seed from the proven parents, obtained from controlled pollinations, could be used to plant up an isolated seed garden from which superior seed would ultimately be obtainable in fair quantity.

Testing of Local Strains.

Another possibility for improved planting material is that there may exist already in the Territory some coconut strains which are above average. Seed from certain localities or plantations, such as Baibara and Karkar, is reputed to be superior, but no accurate comparisons have been made of the performance of palms from these seed types grown together.

An experiment is now being laid down at Keravat to compare the performance of seed from several important areas through the Territory. Seed for the experiment is collected, completely at random, over a fairly large area of a representative plantation, so that it should be typical of that plantation as a whole. This trial is being planted on a newly cleared block some distance from the main planted area of Keravat and a few hundred feet above sea-level, where it is hoped to escape serious *Oryctes* damage.

Final results of this trial can not be expected in less than ten years, while the progeny trial will probably take much longer. In the meantime, it is recommended that growers should concentrate on nursery selection of seedlings for new plantings.

SEEDLING SELECTION.

It was shown in the Ceylon experiment discussed above that nursery-selected seedlings produce earlier bearing and higher yielding palms than did unselected seedlings. Selection is based on two criteria—earliness of germination, and vigour and appearance at the four-leaf stage (about six months old). At the first stage, all seeds which have not germinated within a reasonable period should be rejected. The actual period cannot be stated precisely since rate of germination is influenced by weather conditions. However, a suitable criterion would be to discard all ungerminated nuts as soon as the first 70 per cent. have germinated. At the four-leaf stage, seedlings are selected on colour, size and number of leaves, leggy or unhealthy looking seedlings being rejected. Up to 50 per cent. of the initial seed may be rejected. This makes the seedlings somewhat expensive, but the expense will be more than justified by future performance. The principle is that vegetative vigour is generally quite closely related to yielding ability and the method of seedling selection is simply an early selection on the basis of vegetative vigour.

PALM TYPE COLLECTION.

A collection of different types of palms from all over the Territory was begun at Keravat in 1954, as a possible source of breeding material and for general genetical research. However, this collection, like the palms in the interplanting trial, has been largely frustrated by the activities of *Oryctes*. Less than half the palms planted initially still survive, and the variable damage inflicted on the palms makes it impossible to compare such characters as time of maturity and vigour of different types.

Markham Type Coconut

The Markham type nut is characterized by a very large fruit. A block of these palms was planted at Keravat pre-war, of which a few still survive. These palms were observed to be

variable, many having only normal-sized nuts, but it was not known whether this was due to variability of the strain or to lack of care in obtaining the original seed.

In 1956 the coconut agronomist visited the Markham Valley to try to determine whether the type of nut is growing anywhere there as a pure variety. One European plantation and many native groves were visited, but although a number of individuals of the type were found, they were nowhere present in a pure stand.

A cytological study was made of one palm at Keravat to determine whether the large size of the fruits might be a result of polyploidy. Chromosomes were counted at meiosis, but the number proved to be the normal diploid ($2n = 32$).

Dwarf x Tall Crosses

Work in both Ceylon and India has shown that there may be some commercial possibilities in the use of hybrid seed obtained by crossing dwarf palms with the ordinary tall variety.

Experiments with such crosses at Keravat are impeded by the lack of any mature dwarf palms on the station, although some should come into bearing within a year or two. However, we are grateful to Coconut Products Limited for permission to make crosses on dwarf palms, imported from Fiji, growing on Ralabang Plantation. In February, 1957, 13 flowers were pollinated with pollen from a Markham type palm growing at Keravat and four of these reached maturity. These were harvested in January, 1958, but only two have germinated and one of these is extremely weak.

In July and August ,1958, 33 more pollinations were made, again with pollen from Markham palms. From these, eight nuts reached maturity and were planted in August, 1958, in the nursery at Keravat. All eight have germinated and are growing well.

Bubia

A number of progeny rows from Markham type palms growing on a local plantation have been planted at Bubia (near Lae). These are now about four years old, and doing well.

There are also some seedlings, about two years old, from Fiji. These are progeny from hybrid dwarf palms, bred by Mareschal in 1928.

RURAL ORGANIZATION IN SOUTH-EAST PAPUA

W. COTTRELL-DORMER.

The writer, Regional Agricultural Officer at Samarai, Papua, has established an organization of Village Agricultural Committees through South-East Papua. The committees, with their associated Women's Committees, are proving a strong force in the community not only for economic and agricultural progress, but also for social advancement. Mr. Cottrell-Dormer describes the organization, objectives and work of the committees and outlines future hopes for their development. They have already united into local associations and are developing towards the formation of district councils.

A RURAL organization is being developed in South-East Papua by the Department of Agriculture, Stock and Fisheries. The purpose of this organization in the first instance is to serve as a medium through which to bring agricultural extension activities to the native people in rural communities. But its objectives in the broad sense are more difficult of attainment. These are to develop leadership and to foster good citizenship with all that this implies in economic and social development.

Hence units of the organization are encouraged to interest themselves not only in agriculture, but also in their religion, in public

PLATE 1.—*The author addresses an Association meeting, held out of doors in the Milne Bay District.*

health, education, co-operative enterprise, civics and in all matters which may help the communities towards a fuller and more satisfying life. Their motto is : "Our work is for our people and our villages and our country."

The organization is made up of Village Agricultural Committees and Village Women's Committees. Where the committee work is sufficiently advanced, all the committees in a given linguistic or geographical area are combined into an Agricultural Association, which meets at suitable villages in the area about every four months to discuss and plan the work of the area. The chairmen and vice-chairmen of the associations make occasional patrols of their areas to keep in touch with the committees in their work. The Regional Agricultural Officer is kept informed of these activities and endeavours to attend association meetings, so that he can give advice where required. At present there are eight associations. It will be some time before we move on to the next logical step, the setting up of a District Agricultural Council made up of representatives of the associations, of the Administration, and perhaps of the planting community of other such bodies as it may at that time seem proper to include.

To encourage a sense of unity among the committees throughout the region, a newsletter is sent out to each of them every month, including those areas where no association has yet been formed.

As a further aid to developing this sense of unity and also to widen public interest in the work of the committees, the idea of an annual carnival and agricultural show for each association is being developed. It is impractical to stage District shows in the Samarai area because of communications difficulties. The first carnival was held at the end of 1958 at Waga Waga in Milne Bay and a striking feature was the strong support given to it by the women's committees.

The carnivals are not restricted to the committees, but are meant for all the people of the area and for such other communities as may wish to participate. They are organized by a native carnival sub-committee, chosen or co-opted by the association, with such European guidance and assistance as may be available. As a great deal of work is entailed for the host community, it may not be practicable to stage carnivals each year in each association area. Apart from the difficulties of organization, there is also the risk of causing too much disruption in the normal gardening activities of the people.

Committee Organization

Representation on the committees is on the basis of totemic clans or hamlets, according to the manner in which the particular community is grouped or organized. Each clan or hamlet has one or more representatives, according to its size and importance. Where groups are very small, it is usual for two or more to combine in choosing a representative. Any adult person is eligible for election, including Village Constable, Councillors and members or representatives of other organizations.

Each committee chooses a leader whose duty is to see that regular meetings are held and to report to the chairman of the local association, to the Patrol Officer, or to the Agricultural Officer (or to the Welfare Officer when one is appointed) on the work of his or her committee and on any difficulties which are being encountered. Where there is an association, it is also his or her duty to attend association meetings and there to report on the work of the particular committee. Membership cards are issued by the Agricultural Officer to agricultural committeemen. These have prestige value. Another card is also issued to committee women.

The functions of the Village Agricultural Committees are :—

1. To provide a liaison between the Agricultural Officers and the people.
2. To give leadership to the people in ensuring that sufficient food is grown and that the people participate in an approved manner in programmes for the economic development of the area.
3. To co-operate with constituted authority and with the Women's Committees in improving village life.
4. Generally to give an example of good citizenship.

The functions of the Village Women's Committees are :—

1. To provide a liaison between the Agricultural Officers (and the welfare officer when one has been appointed) and the village women.

2. To give leadership to the women in improving home life and in providing a better environment for the rearing of the village children.

3. To assist in the organization of garden work (both subsistence and economic).

4. To co-operate with constituted authority and with the Village Agricultural Committees in improving village life.

5. Generally, to give an example of good citizenship.

Neither the committees nor the association have any executive authority. Nor is it intended that they should engage in business enterprise in any form, or raise money by levy. It is felt that such activities would end by defeating the objectives of the committtees, which finally are the encouragement of good citizenship. These activities are best handled by Rural Progress Societies, Co-operatives, Village Societies or Councils. However, no objection is raised to the committees encouraging the people to get money together for some simple specific objective, such as a hot air copra drier, a coffee pulping machine, a village sewing machine, or a village pump. Sometimes they organize special plantings of cash crops for these purposes.

At the last count there were about 300 Village Agricultural Committees (throughout the Milne Bay District and in the Abau Subdistrict) and about 150 Village Women's Committees (mainly in the Samarai, Gehua and Esa'ala Subdistricts). However, the number has since increased because the movement is spreading of its own accord and more women's committees have been reported from the Esa'ala and Misima Subdistricts.

It must not be thought that these 450 or more committees are a smooth-working organization, bursting with zeal and activity. This is not the case. All states are to be found, from the moribund to the over-zealous. Nor are they to be thought of as committees in the strict European sense—they may better be termed "groups" of community representatives who have accepted certain responsibilities. Their manner of handling these responsibilities varies from village to village, but is gradually settling down to a definite pattern evolved by the people themselves.

Nor again is it to be expected that our Papuans can step overnight from an almost complete lack of organization in the modern sense to a smoothly-working system which meets all requirements. However, after more than four years' experience, it can be said that the organization is steadily maturing ; that in time it is welcomed by the people ; and that it is achieving results, both domestic and economic. This is particularly the case where women's committees have been established, because they definitely result in fuller acceptance of and participation in our extension programmes by the people generally. In nearly all cases, wherever our agricultural patrols may travel, there are representatives of the people ready to help the patrol and to further its purposes.

These results do not come from merely setting up Committees. They come from the follow-up work which is done afterwards. Where there is insufficient patrolling (especially in the more primitive areas) the people are apt to mistrust the committees and to reject their advice, or alternatively, individual committeemen are apt occasionally to assume powers which they do not possess.

To overcome these difficulties, committeemen and elders are encouraged to come to our training centre for special training and to join in patrols to other areas to see what other committees and communities are doing. During the course of the agricultural patrols, on-the-spot schools and field demonstrations are given in their home areas and elsewhere to committeemen and where desirable, to committee women as well. This is done so that they can learn new techniques and become responsible for the adoption of these techniques by their people.

In addition, local youths and men are taken to the training centre for periods of several months to a year or more so that they can go back and teach their committees and supervise their work. We do not yet have a training centre for girls, so in the women's work we depend largely on the support of the Missions —and so far this has been very good. Even in the primitive areas, where language barriers are sometimes formidable and where committeemen have made some silly mistakes, the organization is developing satisfactorily and producing good results. It will be persevered with because the need for it will increase as economic

development progresses and because it is a useful agency for the preparation of the people for greater prosperity. Also, from the immediate viewpoint, it is a valuable medium in our extension work.

To round off this brief account of our rural organization in South-East Papua, there is one interesting point to add. That is that the organization is giving opportunities for boys and girls to make use of and practise crafts that they have been taught at school. To a worthwhile extent, through the activities of the committees, the older people are beginning to realize that there is a place in village life for the "three R's", home management, infant welfare and other subjects, which in the past were looked on as useless new-fangled notions.

SPECIAL REPORT ON THE DIET OF THE SEPIK RIVER PEOPLE

TOMMY HENRY AND GOTTAE MUIA.

The authors of this report, which was prepared in October, 1957, are two native fieldworkers of the Department of Agriculture, Stock and Fisheries. The report followed extensive patrolling along the Sepik River and is presented here with only minor editorial changes. Mr. Henry and Mr. Muia come from the Milne Bay District and their work in the Sepik was successfully carried out, despite the fact that they were patrolling among people who spoke foreign languages and had a completely different way of life and social organization. Their report proved to be of considerable value to departmental officers working in the Sepik District as it threw new light on local diet and barter trade patterns.

TO speak fully on the diet of the Sepik people will mean pages and pages before we can come to an end. Our chief subject will be mostly the common foods they eat and their barter systems, marketing, the growing of economical groups and other trading enterprises.

The foods they eat are as follows :—

Carbohydrates

Sago (*Metroxlon* spp.); taro (*Colocasia, Xanthosoma* and *Alocasia* spp.); yams (*Dioscorea* spp.); banana (*Musa* spp.); Mami (*Dioscorea* spp.); sweet potato (*Ipomoea batatas*); coconut (*Cocos nucifera*); cassava (*Manihot* spp.); breadfruit (*Artocarpus* spp.).

Proteins

Pork, fish, chickens, ducks, birds, grubs (from dead wood), turtle and crocodile (both including eggs), insects (such as a moth caught in special seasons), wild game (which includes every edible creature in the bush).

Vegetables and greens.

Beans, tomatoes, cabbages, pumpkins, ferns, tulip (*Gnetum gnemon*), bamboo shoots, amaranthus and many others which we don't know. We have included only the ones which we know thoroughly. There are also others which we know only in our own language, which we have left out.

Preparation of Food

A. Sago

Sago is the major food among the entire population of the Sepik and it is cooked by burning and by boiling. By burning, the sago is first mixed in a pot with a little water and when it is thoroughly mixed it is flattened on a piece of iron or broken pot to be burned. When it is cooked, it is taken by hand and eaten, sometimes with fish but very often without any meat. Occasionally the sago is baked by using bamboo containers.

The second method is similar to the making of starch. The sago stumps are dissolved in cold water until a fine, sticky, watery solution forms. Water is boiled and the solution is poured in with constant stirring until it forms into a substance somewhat like starch or porridge. It is then served in native dishes and is usually eaten by hand. However, very often spoons are used.

B. Taro and "Taro Konkon" (Xanthosoma spp.)

It is mostly cooked whole, but occasionally it is cut into small pieces, and when it is cooked, scraped coconut and eschalot are added to make it tasty. It is then poured into bowls and eaten with spoons.

C. Yams, Banana, Mami, Sweet Potato

These are cooked in the same way as with taro. The baking of such foods in hot stones is greatly adopted by the Seventh Day Adventist Missions. According to their religious rules, most of the foods and green stuffs are mashed together on Fridays to preserve them ready for eating on Saturdays.

D. Coconuts

These are used for food, but only in small quantities. Some coconuts are sold.

E. Cassava

Cassava is rare in the area and the method of cooking it is similar to the ways described above.

F. Breadfruit

The seeded one is often burned in the fire and the seeds only are eaten. The unseeded one is mostly cooked on the fire and roasted.

G. Proteins

There are three methods used in processing meat—boiling, roasting and smoking.

Pork, fish, grubs, turtle, crocodiles, insects and some wild game are often processed in these ways. Smoking plays an important part in preserving meat to be kept and used in times when it is hard to find fresh meat.

Chickens, ducks and birds, including the eggs of crocodiles, are often cooked straight away in the pot and eaten, including the gravy. Very rarely roasting is used. Every meat stuff is eaten with carbohydrates, which have been mentioned above. However, moth-like insects are often caught and sometimes boiled. But more often they are wrapped in sago leaves, smoked and then soaked in cold water to soften them before eating.

H. Vegetables and Greens

Generally all vegetable and green stuffs are cooked in pots together, but very often they are mixed with the food and sometimes with the meat.

Barter Trade

So far the barter system appears to be the major trading system among the Sepik peoples. The table will show what sort of food is exchanged, in which villages and for what other goods.

Commencing from Mandibit and downwards, most villages sell their foodstuffs at Angoram. The prices we have noted are, for instance, one copra bag full of yams or mami, £1. This applies also to sago.

With the money they get from the market, they very frequently buy foodstuffs such as rice, meat and fish, but very often the money is spent mostly on clothing and some articles such as eating utensils, fishing lines, hooks, axes, bush knives and other tools.

Village	Exchanges	Receives	At Villages
Sango	Sago	Fish and pots	Pagwi
Japanut	Fish	Sago and pots	Yabom
Kadage	Sago	Fish and pots	Yabom
Earange	Fish and Sago	Pots	Yabom
Kambukmeri	Fish and Sago	Pots	Yabom
Engimwangu	Fish	Sago and pots	Yanget
Shotmeri	Fish	Sago and pots	Wabag
Yajan	Fish	Sago and pots	Yami
Palambe	Fish	Sago and pots	Nagusap
Malingai	Fish	Sago and pots	Yamuk
Kanganeamene	Fish	Sago and pots	Kegerop
Tagawi	Fish and banana	Sago and pots	Gegorub
Chambri	Fish	Sago and pots	Murray
Kamanabit	Fish	Sago and pots	Murray, Yambi, Mulasort, Togwinibit

Sago and fish are traded mostly to other villages; taro, yams, mamies, banana, fowl, etc., are traded to the Government Stations, to the businessman and to other people who wish to buy them.

We found that most of the people along the Sepik River exchange goods. They sell fish to the bush people in exchange for which they get sago. In other villages, they buy pots and stoves by means of exchanging fish and sago. A ready-washed piece of sago, which is approximately one foot long, is worth one big pot or three small pots; more than one foot long is worth one big pot or a big stove. In such villages as Kamburindo, Anduwa, etc., they buy sago and pots for money. A sago six feet to seven feet long is worth 10s.; four feet to five feet long is worth 5s.; the whole palm, about 20 feet to 30 feet, is worth £1 or £2 ; the smaller one, 10 feet to 15 feet, is worth 15s.

The bigger pots, used for ceremonial cooking, are worth £1 and the slightly smaller one is worth 15s. The smaller ones used in daily cooking are worth 5s. to 10s. We do not know their weight.

A hen is worth 10s. and a male is worth 5 s. A bag or half a bag of potatoes is worth 5s. and the same applies to taro. It may even be worth only 3s. to 6s. So it can be seen that these essential articles are not of comparative prices.

Food Preferences and Distribution

In each district in the Territory of Papua and New Guinea, the people eat and grow the foods which are best suited to the majority. The same applies to the foods eaten by the Sepik people.

However the percentages below will show you the food they like best and those, too, which are not eaten very much.

Proportion of diet.

Food.	Per cent.
Sago	45
Yams and mami	30
Fish	10
Meat	8
Bananas	5
Taros	2

This shows that the most popular food is sago and fish and the people seldom eat the other foods.

Ceremonial foods

Generally speaking, the foods used at ceremonial times by the Sepik people are much the same as in other districts. However, there are slight differences.

Ceremonies are held mainly during Christmas, but also at times when a man, child, girl, or woman dies, marriage times, and at the times when they cut a man with a razor or piece of glass to give him a mark. This is mostly in Sepik No. 1, which is looked after by the District Officer and the Assistant District Officer, Ambunti.

At these ceremonies, the people in the villages collect the food on a special day. It is all piled in one or two groups and when the time comes, the women and girls get together and commence cooking, some roasting on stones and some boiling in native saucepans. The men kill pigs, etc.

Food distribution

All along the Sepik River, the sago seems plentiful, but in some villages, such as Sandersi, Kamburindo, Iwarumo, Hagurumara, Kundiman, Agunuim, etc., sago is scarce. Generally speaking, food is plentiful, although some villages do not have as much sago as they would like.

During high water, the people have few taros, yams, mamies, sweet potatoes, etc. This is because the ground is covered with water. Aibon, Saburi and Timbunmeri are not always short, because the people plant their crops on the mountains during high water and along the river banks during the dry season, or low water.

Labour distribution

The cooking is done by the women and girls. Women cook the food, men only eat. Women clear the scrub for the making of gardens and men cut down the big trees. Men and women plant the crops, but the harvesting is done by the women.

Cash crops

Rice and peanuts are the most important, and most villages are planting them. These crops are high priced. Most of the rice and peanuts are sold to the Government at Ambunti and Angoram. Sago, fish and native pots are also sold.

Eating habits

The people in this area use tin plates, mugs spoons, etc., which are bought from the stores. The people have two meals a day, breakfast and supper.

We hope their diet in the future will change slightly, not to let them eat only sago all day or at every meal, but to introduce them to some of the crops which will help change their diet and get them to eat some of the newly-introduced vegetables.

TWO WEEVIL PESTS OF COFFEE IN NEW GUINEA (*Coleoptera*).

SIR GUY A. K. MARSHALL.

SINCE the acceptance of this paper for publication, we regret to announce that news has been received of the death, in London on 8th April, of Sir Guy Marshall, at the age of 87.

Sir Guy Anstruther Knox Marshall, born in India in 1871, the son of a Punjab District Judge, was Director of the Imperial (now Commonwealth) Institute of Entomology from 1913 to 1942. He contributed numerous papers and other publications on Entomology and was honoured by being created a Knight in 1930 and Knight Commander of the Order of St. Michael and St. George in 1942. He also received an honorary Doctorate of Science from Oxford University.

Following his retirement as Director, Sir Guy maintained an active connection with the Institute and British Museum and provided valuable assistance to the Science of Entomology in Papua and New Guinea, mainly in identification of the Curculionidae (weevils), a beetle family, in the taxonomy of which he was a world authority.

IN a small collection of *Curculionidae* received for identification from Dr. J. J. H. Szent-Ivany, Entomologist, Department of Agriculture, Stock and Fisheries, Port Moresby, were two species that were noted as being of some importance as pests of coffee. They both proved to be new to science and are described below. The types are in the British Museum (Natural History), and cotypes in the collection at Port Moresby.

Subfamily OTIORHYNCHINAE.

Oribius cinereus sp. n. (Fig. 1)

Male and female. Derm shiny black, with dense uniform pale grey scaling. *Head* sparsely shallowly punctate and densely squamose; the frons flat, with a small elongate median fovea; the eyes nearly flat, not, or very slightly, exceeding the curvature of the head. *Rostrum* about as long as broad, widening from the base to the genae, with the sides straight; the dorsal area narrowing from the base to the antennae, flat, with dense scales and recumbent ribbon-like setae, the margins not carinate; the genae with long pale recumbent setae, but no scales.

FIG. 1.—*Oribius Cinereus* Mshl. sp. n. male.

(Manuscript received 24th December, 1959.)

hind tibiae of the male with a very small angulation on the lower edge at one-fourth from the apex.

Length 4 to 5 mm.

New Guinea: Madang, Sub-district, Saidor

ERRATUM.

TWO WEEVILS OF COFFEE IN NEW GUINEA.

Date of receival of manuscript should read 24th December, 1958.

TWO WEEVIL PESTS OF COFFEE IN NEW GUINEA (*Coleoptera*).

Sir Guy A. K. Marshall.

FIG 2.—*Meroleptus Cinctor* Mshl. sp. n. male.

Antennae red-brown, the scape with pale recumbent setae, the funicle with the two basal joints equal. *Prothorax* as long as broad, rounded laterally, widest behind the middle, the truncate apex distinctly narrower than the base ; the dorsum moderately convex longitudinally, the punctures concealed by the dense scales and only the very small shiny granules showing through, each giving rise to a short recumbent spatulate white seta, these latter being more conspicuous at the base and sides. *Elytra* broadly ovate, widest before the middle, rather abruptly acuminate at the apex in the female, rather more gradually narrowed in the male, but otherwise extremely similar to the female ; the dorsal outline moderately convex, highest at the middle, becoming rather abruptly perpendicular at the apex, the shallow striae with small separated punctures that show clearly through the dense scales; the intervals broader than the striae, flat, with a row of short curved suberect setae, some white and some grey, more conspicuous on the declivity. *Legs* black, with dense grey scales and white recumbent setae ; hind tibiae of the male with a very small angulation on the lower edge at one-fourth from the apex.

Length 4 to 5 mm.

New Guinea : Madang Subdistrict, Saidor, Windiluk Village, 3,000 feet, 1 male, 2 females, vii. 1958 (*B. R. Johnston*).

The adults cause considerable leaf-damage to *Coffea arabica.*

The absolutely uniform dense pale scaling distinguishes this insect from all the species of *Oribius* described so far, as also the angulation on the hind tibiae of the male.

Oribius hostis Mshl.

When describing this species (Bull. Ent. Res. 48, 1957, p. 4, fig. 3) I unfortunately overlooked the fact that Heller has described a *Coptorhynchus hostis* (*Nova Guinea,* 17, 1935, p. 165) which, judging by the description, almost certainly belongs to the genus *Oribius.* I therefore suggest *inimicus* nom nov. as a new name for *hostis* Mshl.

Subfamily CRYPTORHYNCHINAE.

Meroleptus cinctor sp. n. (Figs 2, 3).

Male and Female. Derm dull black, with brown scales, often indistinctly variegated with grey or blackish scales.

Head with rugosely reticulate punctures and short erect scales, this area being abruptly separated from the vertex, which is quite smooth, bare and impunctate. *Rostrum* of the male rugosely punctate throughout, with three narrow carinae from the base to the antennae, the basal half with suberect peg-like scales ; rostrum of the female with strong close punctures on the basal half only, the apical half shiny, with fine sparse punctures. *Prothorax* subglobose, longitudinally convex, as long as broad, strongly rounded laterally, broadest at about the middle

FIG. 3.—*Meroleptus Cinctor* Mshl. (Lateral view).

and there as broad as the elytra ; the dorsum with comparatively large reticulate punctures which are partly concealed by the dense erect peg-like scales, and on the narrow edges of the punctures are very small scattered inconspicuous shiny granules. *Elytra* subovate, very slightly rounded laterally, widest before the middle, the basal margin truncate and a little wider than the base of the prothorax ; the dorsum rather strongly convex longitudinally, the shallow striae with comparatively large punctures, the intervals about as wide as the striae and bearing a row of small separated shiny granules ; the general scaling small, noncontiguous, recumbent, but intervals 3 and 5 with a discontinuous row of rather dense erect scales. *Legs* coarsely punctate, the femora with recumbent, the tibiae with erect scales, the hind femora not quite reaching the apex of the elytra, the tibiae not carinate dorsally. *Venter* with ventrite 2 a little longer in the female than in the male.

Length 3.5 to 4.5 mm.

New Guinea : Kapumalik Plantation, Bena River, 4,800 feet, Eastern Highlands, 1 male (type), i. 1956 (*J. H. Barrett*); Goroka, Eastern Highlands, 1 female xii. 1954 (*R. S. Carne*); Goroka, 5,400 feet, 6 males, 4 females, bred from pupae in *Coffea arabica* x. 1957 (*J. H. Barrett*); Aiyura, Eastern Highlands, 1 female, bred from larva in coffee stem, x. 1956 (*A. J. Schindler*), 1 female, x 1956 (*R. S. Carne*); *Dutch New Guinea* : Res. Hollandia, Kota Nica, 1 male, 1 female bred from sweet potato, iv. 1958 (*R. J. Simon Thomas*).

This species is closely allied to *M.squalidus* Mshl. (1914), from the Setakwa River, Dutch New Guinea, which is rather larger and differs in having the prothorax constricted at the base, so that the sides are there parallel for a short distance ; the elytrae are more steeply declivous behind, the granules are larger and much more conspicuous, and the basal margin is strongly denticulate.

Dr. J. J. H. Szent-Ivany, when forwarding the specimens, stated that this weevil was the worst pest of *Coffea arabica* in the Territory, the larvae extensively girdling the stems of many trees.

Book Review—HANUNOO AGRICULTURE IN THE PHILIPPINES

(By Harold C. Conklin, Forestry Development Paper No. 12. Food and Agriculture Organization of the United Nations. Rome 1957.)

IN this paper, the author has presented a most informative rural sociological study of a small subsistence farming community in the uplands of the island of Mindoro in the Philippines. Dr. Conklin reveals an intimate knowledge of the traditional form of shifting (" Swidden ") agriculture practised by these people in which the three starch-staples—grains (chiefly rice), bananas and root crops—constituting the bulk of the Hanunoo diet are produced.

The reader is told of social sanctions and religious taboos and rituals influencing or dictating various phases of the pattern of " swidden " agriculture. To the more casual observer, such factors are not so apparent and are not so readily available.

This study emphasizes that the primitive shifting cultivator is a man geared to traditional methods of farming. Rather than seek to modify or introduce improved farming techniques, he follows a pattern of repeated croppings interspersed by longer periods of bush fallowing. However, as the author clearly shows, there are integral variables of custom and sanction which exert a determining role in this regular cycle of site selection, cutting, burning, cropping and fallowing.

Although it is more usual for shifting agriculture not to be practised in grassland, edaphic-biotic complexes may sometimes result in the cultivated lands reverting to tropical savannah rather than secondary forest. This is a common phenomenon in certain areas of New Guinea, particularly in the highland regions. A feature in which shifting cultivation in New Guinea differs from the Hanunoo " swidden " agriculture is that the starch staples in New Guinea are variously root crops, bananas and sago.

It is some years since the publication of K. J. Pelzer's study " Pioneer Settlement in the Asiatic Tropics ", concerning studies in land utilization and agricultural colonization in South-East Asia. To the student of rural sociology, " Hanunoo Agriculture in the Philippines " can be strongly recommended as a most intensive and revealing study of one form of traditional shifting agriculture in the Asiatic tropics.

—*J. W. B.*

W. S. Nicholas, Government Printer.—1678/7.59.

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